RED HILL CREEK EXPRESSWAY (NORTH - SOUTH SECTION) AND Q.E.W. INTERCHANGES (RED HILL CREEK EXPRESSWAY AND BURLINGTON STREET)

Philips Planning + Engineering Limited

RED HILL CREEK EXPRESSWAY (NORTH - SOUTH SECTION) AND Q.E.W. INTERCHANGES (RED HILL CREEK EXPRESSWAY AND BURLINGTON STREET)

Impact Assessment and Design Process
Surface Water and Stormwater Quality
Technical Report

July 1998

PHILIPS PLANNING AND ENGINEERING LIMITED
3215 North Service Road, Box 220
Burlington, ON
L7R 3Y2

Telephone (905) 335-2353
Facsimile (905) 335-1414

admin@philipsconsultants.on.ca

CONTENTS

Section **Page**

APPENDICES

RED HILL CREEK EXPRESSWAY (NORTH - SOUTH SECTION) AND Q.E.W. INTERCHANGES (RED HILL CREEK EXPRESSWAY AND BURLINGTON STREET)

IMPACT ASSESSMENT AND DESIGN PROCESS SURFACE WATER AND STORMWATER QUALITY TECHNICAL REPORT

1. INTRODUCTION

This report has been prepared for the Regional Municipality of Hamilton-Wentworth as part of the Red Hill Creek Expressway (North-South section) and Q.E.W. Interchanges (Red Hill Creek Expressway and Burlington Street) Impact Assessment and Design Process. This report provides a detailed description of the analysis and assessment methodology which are reported in summary form in the "Red Hill Creek Expressway North-South Section Impact Assessment and Design Process Draft Summary Report, Volume 1, November 1997 and Volume 2, July 1998.

1.1 Purpose

This report is intended to assist various stakeholders in identifying and evaluating the impacts of the proposed North-South section of the Red Hill Creek Expressway and the interchange connections at the Q.E.W. (including Burlington Street) on the surface water and stormwater quality of the Red Hill Creek. In addition, this report identifies and evaluates techniques which are proposed to mitigate the predicted impacts to surface water and stormwater quality. Mitigation opportunities associated with "Natural Channel Design" and changes to the Red Hill Creek Channel are reported under separate cover; notwithstanding, the overlap in both impacts and mitigation opportunities has been recognized and discussed accordingly.

1.2 Scope

This report includes:

- background information overview and government policy and regulatory framework
- summary of baseline (current) hydrologic and hydraulic conditions within the Red Hill Creek Valley
- assessment of the impacts of construction of the proposed expressway within the Red Hill Creek Valley and Q.E.W. Interchanges on surface water flows and in-stream water quality of the Red Hill Creek
- screening of various mitigation techniques available to address the predicted impacts
- assessment and evaluation of the proposed mitigation to address the predicted impacts

This report is based primarily on field inventory and analysis carried out as part of the Red Hill Creek Watershed Plan, as well as supplementary analysis of the proposed expressway design.

The reporting of impacts and mitigation is separated into two sections of the expressway:

- *Red Hill Creek Expressway (Mud Street to Brampton Street):* - which includes the section of the Red Hill Creek within the Red Hill Creek Valley, all ramps and the Mud Street interchange

- *Q.E.W. (Highway 20 to Burlington Street):* - which includes the Burlington Street and Red Hill Creek interchanges with the Q.E.W., as well as modifications to the Q.E.W. core and collector lanes. Four alternative Burlington Street Interchange Options identified as Options A, B, C and C1, have also been evaluated as part of this process.

2. BACKGROUND INFORMATION

2.1 Prior Approval And Assessment Framework

The Impact Assessment and Design Process (including the evaluation of mitigation opportunities) has been completed in accordance with the process outlined in the following documents:

- *Proposed Assessment Process, Red Hill Creek Expressway North-South Section, February 1996, Regional Municipality of Hamilton-Wentworth*

- *Exemption Order, Red Hill Creek Expressway North-South Section, February 1996, Regional Municipality of Hamilton-Wentworth*

In addition, as required by the 1985 Joint Board Decision, original Conditions of Approval relating to surface water and stormwater quality, have been integrated into the assessment of impact and selection of mitigation opportunities. The primary conditions which relate to surface water and stormwater quality are contained in Schedule "C" of the Joint Board Decision, as follows:

> *"(1) The following shall be substituted for Schedule "C" to the decision of the Joint Board.*
>
> *"Conditions - the Conservation Authorities Act"*
>
> *That the works be constructed in accordance with the recommendations of the hydrologist Larry Thompson, as stated in evidence by him on January 16, 1986 (or as may be modified, through the detailed engineering design process) with respect to: the size and elevation of creek channels and culverts, the type of materials to be used for lining the channels, the size and elevation of openings through the two railroad embankments, and the size and elevation of stormwater storage areas.*
>
> *That the detailed proposals for the placing of fill, erosion control, sediment control during construction and the phasing of the works (as related to minimizing possible impacts during the actual construction) be submitted to the Hamilton Region Conservation Authority for approval. However nothing in this condition will interfere with the issuance of the permit pursuant to S.28(3) of the Conservation Authorities Act or the overall proceeding of the project in accordance with the decision of the Joint Board."*
>
> *(2) There shall be added a Schedule "D" to form part of the decision as follows:*
>
> *"Conditions - the Lakes and Rivers Improvement Act"*
>
> *That detailed construction and design plans be submitted to the Ministry of Natural Resources for review and approval pursuant to the Lakes and Rivers Improvement Act."*
>
> *The decision of the Joint Board is otherwise confirmed."*

2.2 Background Documents

Three primary sources of information have been utilized to complete this report:

- previous technical studies related to the Red Hill Creek Valley
- Red Hill Creek Watershed Plan and Technical Studies
- various research and case studies related to determining impacts of roadways on Surface Water and Water Quality.

2.2.1 Previous Technical Studies

The following reports have been used as primary background references in this assessment

- *"Supplemental Analysis of Q.E.W.- Red Hill Creek Interchange - Spill Mitigation Evaluation", November 1996, Philips Planning and Engineering Limited*

- *"Drainage Stabilization and Assessment Study Implementation Plan, Red Hill Creek ", November 1992, Philips Planning and Engineering*

- *"Drainage Stabilization Re: Grades Separations at TH&B, King St. and Queenston Road, Red Hill Creek ", November 1991, Philips Planning and Engineering Limited*

- *"Hydraulic Analysis of Proposed Red Hill Creek Expressway, Red Hill Creek ", May 1990, Philips Planning and Engineering Limited*

- *"Hydraulic Analysis and Detailed Design of TH&B to north of Queenston Road", November 1989, Philips Planning and Engineering Limited*

- *"King Street Interchange - Detailed Hydraulic Analysis", August 1989, Philips Planning and Engineering Limited*

- *"Mountain East-West and North-South Transportation Corridor - Drainage Study - Final Report" - July 1989, Philips Planning and Engineering Limited*

- *"Effect of Proposed North-South Expressway on Peak Flows and Levels in Lower Red Hill Creek", November 1983, Paragon Engineering*

2.2.2 Red Hill Creek - Watershed Plan

The Red Hill Creek - Watershed Plan and technical studies completed as part of the Watershed Planning process have also been used to characterize surface water flow and stormwater quality issues. Specifically the hydrologic and hydraulic models completed for the Watershed Plan have been used as basis for detailed analysis, completed for this assessment. Additionally, the stormwater quality mass balance modelling completed as part of the Watershed Plan and water quality characterization, (based on assembly of results of a number of sampling programs and studies as part of Watershed Plan) has been used as the

basis for assessment of water quality impacts and pollutant loading of the expressway, in the context of loading from the remainder of the watershed.

2.2.3 Related Research and Case Studies

Research and other case studies have also been used to determine and quantify potential impacts of the expressway works on surface water flow and stormwater quality. In addition, information from various reports and models has been used to evaluate the relative effectiveness of various mitigation options. A number of studies have been specifically referenced for this assessment including:

- *"Heavy Metals in Highway Bridge Runoff , 1997, National Water Research Institute , Environment Canada, Marsalek J., Brownlee B., Mayer T,. Lawal S., and Larkin G.*
- *"Performance Assessment of an Off Line Stormwater Management Pond: Heritage Estates Stormwater Management Pond, Richmond Hill, Ontario", 1996 Prepared for MOEE and Metro Toronto & Region Conservation Authority, Liang, W.Y. and Thompson M. K.*
- *"The Effect of Motorway Runoff on Freshwater Ecosystems 1. Field Study" and "2. Identifying Major Toxicants", 1995, University of Sheffield, Maltby L., Forrow D. M., Boxall, A. B. A., Calow P., and Betton C.*
- *"A Review and Evaluation of Literature Pertaining to the Quantity and control of Pollution from Highway Runoff and Construction", April 1993, Centre for Research in Water Resources, University of Texas, Malina J. F. Charbeneau R.J., Ward G.H. and Barrett, M, Zuber R.D. Collins E.R.*
- *"Natural Wetlands and Urban Stormwater: Potential Impacts and Management", 1993 Office of Wetlands, Oceans and Watersheds, Washington, DC, United States Environmental Protection Agency*
- *"A Current Assessment of Urban Best Management Practices - Techniques for reducing Non-point Pollution in the Coastal Zone", March 1992 Metropolitan Washington Council of Government, Schueler, T. R., Kimble, Heraty, P. E.*
- *"Constructed Wetlands for Stormwater", 1992 Ministry of Environment and Energy (MOEE)*
- *"Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetlands in the Mid-Atlantic Region", 1992 Anacostia Restoration Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, Schueler, T. R.*

3. GOVERNMENT POLICY AND REGULATORY FRAMEWORK

Government Policy and legislation relating to control of surface water flow (flooding and erosion and water quality) is based on three primary sources:

- Riparian Law (Common Law)
- Statute Law and Regulations
- Site specific plans (Remedial Action Plans, Watershed Plans)

Riparian Law or Common Law provides the basic principles which govern the rights and obligations of riparian landowners (landowners adjacent to watercourses). The principles of riparian law include obligations of riparian owners to accept damages due to natural flooding, as well as obligations to ensure that land use changes and other actions do not adversely affect flooding and erosion conditions on upstream and downstream properties.

Statute laws concerning surface water flow include Federal, Provincial and Municipal policies and regulations, which prescribe standards and approval requirements for construction of drainage works, restrictions on alteration to watercourses and flood plains, as well as restrictions on construction within flood susceptible areas.

Legislation related to water quality include Federal and Provincial standards and objectives for drinking water and surface water bodies (i.e. streams lakes ponds etc), Provincial guidelines for stormwater treatment as well as Provincial regulations and Municipal by-laws, which govern the quality of effluent which is discharged to receiving water bodies.

Objectives and targets for the quality of runoff in the Red Hill Creek have also been set through the Hamilton Harbour Remedial Action Plan (RAP), as well as through the current Red Hill Creek - Watershed Plan.

3.1 Surface Water (Hydrology and Hydraulics)

The primary regulations and policies which would relate to surface water flow in Red Hill Creek, include:

- *Federal Fisheries Act* - Authorization and Compensation requirement for destruction-alteration of Fish Habitat
- *Navigable Waters Protection Act* - Regulates changes to watercourse which impact on Navigable Waters
- *Environmental Protection Act* - requires approval of stormwater management and sewer works
- *Conservation Authorities Act* - Fill, Construction and Alteration to Waterway Regulations
- *Lakes and Rivers Improvement Act* - requires approval for works within watercourses
- *Water Resources Act* - requires approval for diversion of flow
- *Municipal By-Laws* - relate to site drainage and connections to drainage works

3.2 Stormwater Quality

There are several policies and regulations related to the quality of surface water and discharge to receiving watercourses. Primary legislation includes:

- *Provincial Water Quality Objectives*
- *Sediment Quality Management Guidelines*
- *Ontario Drinking Water Objectives*
- *Canadian Water Quality Guidelines*
- *Ministry of Environment and Energy Stormwater Management Practices - Planning and Design Manual*
- *Recommendations of the Hamilton Harbour Remedial Action Plan (RAP)*

The Provincial Water Quality Objectives (PWQOs) give direction on how to manage the quality and quantity of surface waters. The acceptable levels of constituents provided in the PWQOs ensure that water quality is satisfactory for aquatic life and human recreation. While the PWQOs are useful indicators of aquatic ecosystem health, they cannot however be viewed as direct measures, since non-chemical factors, such as habitat loss, also have significant impact on aquatic ecosystems.

In addition to contaminants in the water column, contaminated sediment can also have significant impact on aquatic organisms. The Ontario Sediment Quality Management Guidelines, produced by the Ministry of Environment and Energy, provides management directives for contaminated sediments and details the protocol for setting the guidelines.

The Ontario Drinking Water Objectives are normally applied to drinking water supplies for the protection of public health. In some cases however, aesthetic objectives may be used in characterizing surface water sources.

The recommendations of the Hamilton Harbour Remedial Action Plan (RAP) encompasses numerous aspects of water quality issues, including recommendations for actions intended to reduce sediment, contaminant and bacteria loading to the harbour.

While there are many additional documented guidelines, these are considered the most commonly used as a benchmark for assessing the quality of the waters in Ontario, and act as a measure of ecosystem health.

The Ministry of Environment and Energy - Stormwater Management Practices Planning and Design Manual provides guidelines for Stormwater Best Management Practices (BMP) for new development.

3.3 Red Hill Creek - Watershed Plan - Targets/Objectives

Based on the Watershed Plan process, the following targets for surface water and stormwater quality have been identified:

- improve water quality with a focus on ammonia and toxic metals
- make streams safe for recreational use by achieving 100 ppm coliform (Provincial standard)
- maintain a stable natural channel form related to the urban flow regime
- reduce 100 return frequency year peak flows to approximately 83 m^3/s at the Q.E.W. (i.e. to the point of overtopping)
- ensure no increase in adverse flood potential to property in accordance with riparian doctrine

These targets and objectives must be considered when evaluating impacts caused by the expressway works and when formulating mitigation measures to address these impacts.

4. BASELINE INVENTORY

4.1 General

The existing surface water flow conditions and stormwater quality within the Red Hill Creek are directly attributable to the land use and drainage characteristics of the contributing watershed area.

The Red Hill Creek Watershed encompasses an area of approximately 68 km^2. The watershed is located within the limits of the Regional Municipality of Hamilton-Wentworth, draining lands within the City of Hamilton, Township of Glanbrook and City of Stoney Creek.

The majority of this land base is generally characterized by mild gradients (1% to 2%) within table land areas (i.e. above valley features), and primarily by clay and clay-loam soils, that exhibit moderate to high runoff potential (i.e. hydrologic soil classes C and D).

The Red Hill Creek Watershed exhibits a primarily urban land use, with development historically proceeding from the creek's outlet at Hamilton Harbour (Windermere Basin), southerly towards the headwater areas located above the Niagara Escarpment.

The Red Hill Creek Watershed is characterized by a preponderance of urban drainage systems. There are a total of 58 outfalls to the Red Hill Creek and its tributaries (ref. Red Hill Creek Wateshed Plan). Although not all of these sewers outlet directly to the Red Hill Valley in the vicinity of the expressway, all of the outlets contribute flow which ultimately affects magnitude of flow within the Red Hill Creek.

Approximately 60% of the watershed's land surface drains via urban sewer systems. Approximately 45% of the sewer systems within the Red Hill Creek Watershed are combined (storm and sanitary sewer systems). Urban developments within the City of Hamilton, typically feature direct connection of roof leaders to the storm sewer system, and hence a relatively high level of impervious areas are directly connected to the storm sewer system.

The remaining 40% of the watershed features "natural drainage" in which runoff has a greater opportunity to flow across pervious land surfaces to ditches and/or watercourses, which in turn discharge to the Red Hill Creek main branch and its tributaries. In some cases, drainage from open watercourses is conveyed through storm sewer systems or enclosures, prior to discharging to the Red Hill Creek.

The Red Hill Creek Watershed is also characterized by a minimal presence of natural wetlands or other significant natural storage areas (such as depressions or pools within the surface topography), particularly within the headwater area (i.e. above the Niagara Escarpment). Hence, retention of runoff within the headwater areas during storm events is generally low. This type of drainage system results in rapid flow response to storm events within the Red Hill Creek, throughout the area of the expressway corridor. Following storm events, streamflow within the Red Hill Creek also typically recedes at a rapid rate and interflow through soils in the headwater area to local tributaries is relatively rapid, within the order of 6 - 18 hours.

4.2 Hydrology

Hydrologic modelling completed as part of the Red Hill Creek Watershed Plan has defined frequency flows for various locations within the Red Hill Creek for existing and future land use conditions (ref. Red Hill Creek Watershed Plan). Tables 4.1, 4.2 and 4.3 provide a summary of the frequency flows at key locations within the Red Hill Creek Valley for three land use conditions considered in the analysis:

Existing Land Use Conditions (without the Dartnall Road Flood Control Facility) (which is located upstream of the Dartnall Road interchange). This is the base condition for comparing expressway impacts since the Dartnall Road facility was constructed as part of the overall expressway project in 1996.

Existing Land Use Conditions including the Dartnall Road Flood Control Facility. These flows reflect the existing conditions in the Watershed today(1998). This is an interim condition in which the Dartnall Road Flood control facility currently serves to reduce downstream flows.

Future Land Use Conditions. These flows are based on future land use conditions (i.e. Official Plan Land Use, including Expressway and "approved" stormwater management facilities in place as outlined in the Red Hill Creek Watershed Plan). These flows would be considered as the long term or ultimate flow conditions; they provide an indication of hydrologic impacts of the proposed expressway and future land use.

TABLE 4.1

FREQUENCY FLOWS (m^3/s)

Existing Land Use
(without Dartnall Road Flood Control Facility In-Place)

Location	Node	Frequency (years)									
		1.003	1.05	1.25	2	5	10	20	50	100	Regional
Outlet @ Windermere	10.010	16	21.9	30.2	45.2	71.7	92.9	116	149	177	469.7
	10.020	18.8	26.1	35.8	52	78.3	98.2	119	148	172	489.3
CNR	10.030	18.8	26.1	35.8	51.9	78.3	98.1	119	148	172	488.7
	10.040	18.9	26.2	36.0	52.0	78.1	97.7	118	147	170	484.6
Barton St.	10.041	19.0	27.2	37.7	54.6	81.4	101	122	150	173	487.2
Melvin St.	10.050	18.9	27.1	37.6	54.5	81.3	101	121	147	173	487.1
	10.060	0.16	0.26	0.36	0.50	0.67	0.79	0.89	1.02	1.12	2.64
	10.070	18.5	27.6	38.7	56	82.3	101	120	147	167	476.7
	10.080	18.5	27.6	38.7	56	82.4	101	121	147	168	475.2
Queenston Rd.	10.090	18.6	29.1	41.4	59.5	86	104	123	147	166	480.7
	10.100	18.4	29.7	42.7	61.5	88.4	107	125	149	168	473.7
D/S of King St.	10.110	18.7	30	42.9	61.7	88.4	107	125	148	167	474.9
	10.111	18.7	30.1	43.2	61.9	88.6	107	125	148	166	474.8
Red Hill u/s of King St.	10.120	16.0	25.1	35.6	50.8	72.7	87.7	102	122	137	362.7
	10.121	0.7	1.03	1.42	2.02	2.93	3.57	4.21	5.07	5.76	19.40
TH&B	10.130	15.9	25.1	35.5	50.4	71.5	85.8	99.7	118	132	354.3
	10.140	15.6	25.1	35.7	50.6	71.3	85.2	98.7	116	130	351.1
Red Hill @ Greenhill Outlet	10.141	16.6	26.0	36.5	51.1	71.4	85.0	98.1	115	128	349.0
	10.150	10.9	14.4	18.9	26.1	37.7	46.2	55.1	67.4	77.3	221.8
	10.151	11.3	15.4	20.4	28.0	39.6	47.9	56.2	67.5	76.5	216.0
Albion Falls	10.160	10.5	14.5	19.2	26.5	37.3	45.0	52.7	63.1	71.3	201.7
	10.161	10.8	15.2	20.3	27.8	38.4	45.7	52.9	62.5	69.8	200.7
	30.010	5.21	8.3	11.3	15.1	19.8	22.7	25.3	28.6	31.0	99.23

(Note: For nodal reference points refer to Red Hill Creek Watershed Plan and supporting technical documentation).

TABLE 4.2
FREQUENCY FLOWS (m^3/s)

Existing Land Use
(with Dartnall Road Flood Control Facility In Place)

LOCATION	NODE	Frequency (years)									
		1.003	1.05	1.25	2	5	10	20	50	100	Regional
Outlet @ Windermere	10.010	15.1	19.8	26.9	39.8	63.4	82 6	104	135	162	469 7
	10.020	17.4	23.6	32.0	46.0	69.2	86.8	105	132	153	489.3
CNR	10.030	17.5	23.6	32.0	46.0	69.1	86.8	105	132	153	488.7
	10.040	17.6	23.8	32.1	46.0	69.0	86.4	105	131	152	484.6
Barton St.	10.041	17.5	24.4	33.3	48.0	71.8	89.6	108	134	155	487.2
Melvin St.	10.050	17.5	24.3	33.3	48.0	71.7	89.4	108	134	155	487.1
	10.060	0.16	0.26	0.36	0.50	0.67	0.79	0.89	1.02	1.12	2.64
	10.070	17.2	24.7	34.0	48.8	71.9	88.7	106	130	148	476.7
	10.080	17.0	24.5	34.0	48.9	72.2	89.1	106	130	149	475.2
Queenston Rd.	10.090	17.2	25.8	36.2	52	75.6	92.2	109	131	149	480.7
	10.100	16.8	26.2	37.1	53.4	77.1	93.6	110	132	149	473.7
D/S of King St.	10.110	16.9	26.3	37.3	53.6	77.3	93.8	110	132	149	474.9
	10.111	17.1	26.5	37.5	53.8	77.5	93.9	110	132	149	474.8
Red Hill u/s of King St.	10.120	14.5	21.8	30.3	43	61.5	74.4	87.1	104	118	362.7
	10.121	0.7	1.03	1.42	2.02	2.93	3.57	4.21	5.07	5.76	19.4
TH&B	10.130	14.5	21.7	30.1	42.4	60.0	72.2	84.1	100	112	354.3
	10.140	14.5	21.9	30.3	42.4	59.7	71.5	83.1	98.3	110	351.1
Red Hill @ Greenhill	10.141	15.0	22.7	31.2	43.2	59.8	71.0	81.8	95.9	107	349.0
	10.150	9.79	11.8	14.5	19.1	26.8	32.7	39.0	48.0	55.3	221.8
	10.151	9.83	12.1	15.0	19.7	27.3	33.0	38.9	47.2	53.9	220.0
Albion Falls	10.160	9.34	11.6	14.4	18.8	25.7	30.7	35.7	42.7	48.3	201.7
	10.161	9.44	11.9	14.8	19.4	26.4	31.3	36.3	43.1	48.5	200.7
	30.010	3.69	3.97	4.31	4.8	5.53	6.03	6.54	7.21	7.73	99.23

(Note: For nodal reference points refer to Red Hill Creek Watershed Plan and supporting technical documentation).

TABLE 4.3

FREQUENCY FLOWS (m^3/s)

Future Land Use
(with Dartnall Road Flood Control and "Approved"[1.] Stormwater Management Facilities In-Place)

Location	Node	Frequency (years)									
		1.003	1.05	1.25	2	5	10	20	50	100	Regional
Outlet @ Windermere	10.010	19.1	25.4	34.2	49.5	75.6	95.9	118	149	174	476
	10.020	21.4	29	39	55.1	81.1	100	120	148	171	492
CNR	10.030	21.5	29.1	39	55.1	81	100	120	148	171	493
Barton St.	10.040	21.5	29.2	39.2	55.3	81	100	120	147	169	490
	10.041	21.4	30	40.7	57.8	84.4	104	124	151	173	490
Melvin St.	10.050	21.4	29.9	40.7	57.7	84.3	104	123	151	172	489
	10.060	0.16	0.26	0.36	0.5	0.67	0.79	0.89	1.02	1.12	2.53
	10.070	20.9	30.2	41.4	58.6	84.3	103	121	146	166	486
	10.080	20.7	30.1	41.5	58.7	84.6	103	121	146	166	484
Queenston Rd.	10.090	20.8	31.5	43.9	62	88.1	106	124	147	166	492
	10.100	20.2	31.9	45	63.8	90.3	108	126	148	166	489
D/S of King St.	10.110	20.2	32	45.3	64.1	90.4	108	125	148	165	486
	10.111	20.4	32.3	45.5	64.3	90.6	108	125	148	165	484
Red Hill u/s of King St.	10.120	16.7	24.7	34	47.7	67.6	81.4	95.1	113	127	371
	10.121	1.16	1.75	2.37	3.18	4.23	4.9	5.53	6.32	6.91	19.0
TH&B	10.130	16.6	24.4	33.4	46.6	65.6	78.6	91.5	109	122	362
	10.140	16.6	24.4	33.4	46.4	65	77.7	90.1	107	119	356
Red Hill @ Greenhill Outlet	10.141	17.2	25.1	34	46.8	64.7	76.8	88.6	104	116	352
	10.150	11.8	14.4	17.9	23.5	32.6	39.3	46.3	56.2	64.1	231
	10.151	11.8	14.7	18.4	24.3	33.3	39.9	46.6	55.8	63.1	225
Albion Falls	10.160	11.3	14.3	18	23.4	31.6	37.4	43.2	51	57.1	218
	10.161	11.3	14.6	18.4	24.1	32.3	38	43.7	51.2	57.1	218
	30.010	4.26	4.75	5.21	5.77	6.46	6.87	7.24	7.69	8.02	107

[1.] Refers to proposed Stormwater Management facilities which are currently in-place through land use planning processes, have received some level of planning approval or are currently under consideration through land use planning processes (ref. Red Hill Creek Watershed Plan)

(Note: For nodal reference points refer to Red Hill Creek Watershed Plan and supporting technical documentation).

A comparison of existing and future land use flows indicates the following general trends:

- Increases in peak flow rates under Future Land Use would be low to moderate, which is typical for a partially urbanized watershed, (i.e. where the significant area of existing development currently provides a high storm flow response), hence further urbanization does not produce as large an increase in peak flow rates,

- The greatest relative increase in frequency flows is exhibited under frequent storm events (i.e. 1 to 2 year return frequency). It is these more frequent storm events which are most closely linked to erosion and stream forming processes. Erosion potential would be expected to increase as future urban development proceeds,

- Increases in peak flow rates for severe storm events (i.e. 50 to 100 year return periods) would be greatest in the upper reaches of the watershed. In the absence of the Dartnall Road Flood Control Facility, increases in flood damage potential as future urban development proceeds would be greatest in the upper reaches of the Red Hill Creek,

- The Dartnall Road Flood Control Facility would reduce 100 year flow rates throughout the main branch of the Red Hill Creek. The magnitude of such reductions ranges from 8.5% at Windermere Basin to 30% immediately downstream of the Dartnall Road interchange,

- The Dartnall Road Flood Control Facility along with other "approved" stormwater management facilities would serve to maintain (future) 50 and 100 year flows to existing levels (without the Dartnall Road Flood Control Facility). This effect is exhibited throughout the main branch of the Red Hill Creek. These results indicate that the Dartnall Road Flood Control Facility would exceed the required flow control required to mitigate increases in peak flow rates caused by the North-South Expressway itself.

4.3 Hydraulic Assessment

The factors which affect river hydraulics of the Red Hill Creek vary significantly throughout its length including:

- lake and harbour water levels
- valley and flood plain topography
- channel slope
- man-made structures, such as bridge and culvert crossings, erosion protection works and channelization works

Three primary reaches have been characterized as follows:

Windermere Basin to Brampton Street

The reaches of the Red Hill Creek located from the outlet at Windermere Basin to approximately Brampton Street, feature low channel slopes, relatively flat topography and wide floodplains The hydraulics of this section are dominated by water levels within Hamilton Harbour/Lake Ontario. Due to the low channel slopes and generally flat topography of this area, channel and overbank flow velocity are low and the floodplains are wide. The elevation of Q.E.W., which is located adjacent to the Red Hill Creek channel through this area, is generally less than 2 metres above the normal water level (i.e. long term mean) within the Hamilton Harbour. As a result, this section of the Q.E.W. is prone to flooding, particularly under severe storm events. This location is one of the primary potential flood damage locations within the watershed.

Brampton Street to base of the Niagara Escarpment

Upstream of Brampton Street to the base of the Niagara Escarpment, the Red Hill Creek is located within an incised valley feature, with moderate to steep channel slopes approaching the Niagara Escarpment. Hydraulics during flood events are primarily affected by man-made bridge and culvert constrictions, as well as by valley/floodplain topography and vegetation. Due to the well-defined valley topography throughout this reach of the Red Hill Creek, flooding is confined to the valley system and potential for flood damage (to human use) is limited to road crossings and recreational facilities.

As noted in the Terrestrial Inventory completed as part of the Watershed Plan, some terrestrial units within the Red Hill Creek are tolerant of periodic flooding and in some cases terrestrial units are dependent on periodic flooding of the valley floor for continued viability. Notwithstanding, others would be expected to be detrimentally affected by frequent flooding, high velocities and sediment/contaminant loads.

Under existing conditions, constriction of flows at the CNR railway embankment is the primary hydraulic influence which affects Regulatory (Hurricane Hazel) flood levels from the CNR to approximately Queenston Road. The backwater created by the existing CNR constriction under Regulatory flood conditions increases flood damage potential at both the Barton Street and Melvin Street crossings.

Base of Niagara Escarpment to Mountain Brow

Hydraulics of the Red Hill Creek traversing the Niagara Escarpment are dominated by the steep channel slope of this reach. Generally, flood damage potential to these areas is considered low.

4.3.1 Hydraulic Modelling and Flood Plain Delineation

The Red Hill Creek has been modelled using the U.S. Army Corps of Engineers HEC-2 model as part of the Red Hill Creek Watershed Plan. The current model has been based on previous hydraulic studies and has been revised as follows:

- Incorporation of 1996-1997 field survey completed as part stream morphology investigations.
- Incorporation of previous stream morphologic surveys completed in 1994 (by WRIS).
- New field survey of specific areas where significant changes in stream location or significant erosion has occurred. (i.e. downstream of King Street).
- Incorporation of hydraulic modelling completed as part of construction of Queenston Road, King Street, TH&B crossings, as well as the Dartnall Road interchange, and the Mountain Industrial Park.
- Changes to the Windermere Basin made as part of the Windermere Basin Rehabilitation.
- Updated spill flow characteristics along the Q.E.W. resulting from safety improvement changes made to the highway (i.e. addition of centre wall.
- Review and verification of stream and flood plain characteristics to previous modelling using current 1:1000 scale mapping obtained from the City of Hamilton (PARCiL Project).

Resulting flood levels for various frequency flood events for locations within the Red Hill Creek Valley are presented in Appendix B.

Table 4.4 provides a summary of general flood plain characteristics for each of the three reaches of the Red Hill Creek for Regulatory flood as well as the 50 year and annual return frequency floods.

TABLE 4.4

SUMMARY OF FLOOD PLAIN CHARACTERISTICS

Reach	Return Frequency Flood Event	Average Flood Plain width (m)	Depth of Flow in Avg. Channel (m)	Channel Avg. Velocity (m/s)	Floodplain Avg. Velocity (m/s)
Windermere to Brampton Street	Regulatory (Hurricane Hazel)	170	3.8	2.3	0.55
	50 year	120	3.2	1.3	0.30
	Annual	72	1.6	0.6	0.07
Brampton St to Base of Niagara Escarpment	Regulatory (Hurricane Hazel)	165 (50-250)	6.3	3.0	0.4
	50 year	96	4.2	1.9	0.20
	Annual	15	1.0	1.7	0.10
Base of Niagara Escarpment to Mountain Brow	Regulatory (Hurricane Hazel)	25	3.6	4.8	0.47
	50 year	14	1.5	3.3	0.08
	Annual	10	0.65	2.1	N/A

4.3.2 Hydraulic Structure Inventory

An updated inventory of hydraulic structures (crossings and enclosures) has been prepared for the main branch of the Red Hill Creek. Table 4.5 provides a summary of the characteristics of each structure. Structure locations are illustrated in Watershed Plan and Expressway Summary Documents.

TABLE 4.5

SUMMARY OF HYDRAULIC CAPACITY OF MAJOR CROSSINGS OF RED HILL CREEK

LOCATION	Type, Configuration & Dimensions (m)	Return Frequency Flow Capacity (years)	
		Culvert /Bridge Capacity (to 1 m Clearance/1 m Freeboard)	To Point of Overtopping
WOODWARD AVE	BRIDGE 30.1 x 3.83 SPAN = 30.1 LENGTH = 14.0	2 year	100 year
RAMP – Q.E.W. TO WOODWARD AVE	BRIDGE 48.0 x 5.15 SPAN = 65.0 LENGTH = 10.0	100 year	Regional
RAMP – BURLINGTON ST. TO Q.E.W.	BRIDGE 48.0 x 5.15 SPAN = 29.6 LENGTH = 37.0	2 year	100 year
BRAMPTON ST. (pedestrian crossing)	BRIDGE 32 x 6.5 SPAN = 32 LENGTH = 4		
CNR (EAST)	CULVERT CONCRETE ARCH 3.9 x 3.4, SPAN = 3.9 LENGTH = 29.0	20 year	100 year
CNR (WEST)	CULVERT CONCRETE ARCH U/S 3.9 x 3.63 D/S 4.2 x 3.77 SPAN = 3.9 LENGTH = 37.0	20 year	100 year
BARTON STREET	CULVERT TRIPLE CONCRET BOX 3.1 X 2.61 SPAN = 9.8 LENGTH = 83.0	10 year	20 year
MELVIN AVENUE	BRIDGE 14.0 x 2.8 SPAN = 14.0 LENGTH = 9.3	1 year	5 year
QUEENSTON ROAD	BRIDGE SPAN = 105.5 LENGTH = 31.91 Concrete Trapezoidal Channel 11.0 x 2.61	50 year (0.5 m freeboard)	100 year (channel capacity) [100 year]
KING STREET	TRIPLE BOX CULVERT 4.6 x 3.3 SPAN = 15.6 LENGTH = 60.0	10 year	N/A
TH & B (CNR) RED HILL CREEK	TRIPLE BOX CULVERT 3.1 x 2.82 SPAN = 10.9 LENGTH = 60.0	20 year	100 year
MOUNTAINBROW BOULEVARD RED HILL CREEK	CULVERT CONCRETE ARCH 6.9 x 4.1 SPAN = 6.9 LENGTH = 15.6	2 year	50 year

4.4 Erosion

An inventory of existing in-stream channelization and erosion protection works has been prepared as part of the Watershed Plan. Typical erosion protection and channelization works present within the existing Red Hill Creek include:

- concrete invert protection (saddles), drop structures, and bank stabilization structures constructed to provide erosion protection for sanitary trunk sewer crossings throughout the Red Hill Creek
- inlet and outlet erosion protection (i.e. concrete or rip-rap) at culverts, bridges and sewer outfalls
- bank stabilization works such as (gabion and armourstone structures) and channelization, particularly associated with golf course usage
- bank stabilization works and channelization associated with the Red Hill Creek Expressway (i.e. Queenston Road and King Street).

Numerous locations have been noted within the main branch of the Red Hill Creek where stream bank failure is evident through such mechanisms as bank sloughing, tree falls and undermining. Figures illustrating locations of these erosion protection works are provided in the Red Hill Creek Expressway Impact Assessment and Design Process Summary Report, Volume 1, November, 1997.

Table 4.6 provides a summary of the various in-stream channelization and erosion protection works and their location within the main branch of the Red Hill Creek. Approximately 16%+/- of existing stream banks currently have some form of artificial revetment.

TABLE 4.6

EXISTING EROSION PROTECTION AND CHANNELIZATION WORKS WITHIN MAIN BRANCH OF RED HILL CREEK

Location	Type of Structure/Work	HEC-2 Station	Dimensions
180 m U/S of C.N.R.	Concrete Channel Lining	2+570 to 2+670	Length = 20 m
260 m U/S of C.N.R.	Concrete Channel Lining	2+570 to 2+670	Length = 15 m
460 m U/S of Melvin Avenue	Concrete Lining – East Bank	3+400 to 3+570	Length = 25 m
505 m U/S of Melvin Avenue	Concrete Lining – East Bank	3+400 to 3+570	Length = 15 m
830 m U/S of Melvin Avenue	Concrete Lining – East Bank	3+650 to 3+750	Length =15 m
150 m D/S of Queenston Road	Rip-Rap	4+482 to 4+498	Length =16 m, Width = 3 m
Queenston Road	Concrete Channel	4+498 to 4+686	Length = 194 m, Width = 11 m
60 m U/S of Queenston Road	Rip-Rap	4+686 to 4+750	Length = 17 m, Width = 3 m
350 m D/S of King Street	Armour stone - West Bank	5+339 to 5+483	Length = 150 m
270 m D/S of King Street	Concrete Channel Lining	5+400 to 5+460	Length = 20 m
100 m D/S of King Street	Armour Stone and Rip-Rap – West Bank	5+460 to 5+552	Length =100 m, Height = 2 m
King Street	Concrete Inlet/Outlet & Channel	5+574 to 5+690	Length =150 m
120 m U/S of King Street	Concrete Channel Lining	5+716 to 5+780	Length = 15 m
315 m U/S of King Street	Gabions – West Bank	5+980 to 6+150	Length =80 m, Height = 1 m
160 m D/s of T.H. & B.	Gabions – West Bank	6+330 to 6+400	Length = 60 m, Height = 2 m
435 m U/S of T.H. & B.	Concrete Channel Lining	6+610 to 6+700	Length = 15 m
Greenhill Park	Rip-Rap – West Bank	7+500 to 7+600	Length = 75 m
1570 m U/S of T.H. & B.	Gabions – East Bank	7+850 to 7+950	Length = 40 m, Height = 1 m
1570 m U/S of T.H. & B.	Gabions – West Bank	7+850 to 8+250	Length = 400 m, Height = 1 m
1690 m U/S of T.H. & B.	Gabions – East Bank	7+950 to 8+100	Length = 50 m, Height = 1 m
2465 m U/S of T.H. & B.	Gabions – East and West Banks	8+750 to 8+906	Length = 140 m, Height = 2.5 m
3000 m U/S of T.H. & B.	Concrete Spillway	9+329 to 9+440	Length = 13 m
3120 m U/S of T.H. & B.	Concrete Spillway	9+467.1 to 9+467.3	Length = 10 m
Total Length of Erosion Protection Works (Windermere to Mountain Brow)			2300 m
Total length of stream banks along Main Branch of Red Hill Creek (Windermere to Mountain Brow - both sides)			(6950 x 2) 13900 m

(Note: Refer to IADP Summary Report, Volume 1, November, 1997, for locations.)

4.5 Water Quality

The water quality of the Red Hill Creek has been characterized, (as reported in the Watershed Plan), based on a number of sampling programs conducted by various agencies and institutions. Generally the water quality of the Red Hill Creek within the valley can be characterized as follows:

- under storm conditions it is generally poor (exceeds Provincial Water Quality Objectives-PWQO) with high loads of suspended sediment, metals, polycyclic aromatic hydrocarbons (PAH), coliforms, and nutrients.
- under low flow conditions most pollutants are within acceptable ranges (i.e. PWQO), high bacterial levels are the major impairment during low flow conditions, as well as some nutrients and metals
- sediment quality within the upper reaches of the Red Hill Creek is generally much better than the lower reaches and Windermere Basin, however this may be a function of stream hydraulics and settling dynamics as opposed to a source or location.
- surveys of benthic invertebrates tend to reflect the findings of water quality and sediment sampling, with pollutant tolerant species forming the primary benthic community within the Red Hill Creek.

Primary sources of pollutants during storm flow include Combined Sewer Overflows, urban runoff, and stream bank erosion (which increases suspended sediment loads).

During low flow, pollutant sources include the Woodward Sewage Treatment Plant (lower reach only), nutrients from the upper watershed and likely inputs from the Upper Ottawa and Brampton Street landfills. The source of high coliforms under low flow is currently unknown.

5. ASSESSMENT OF PROJECT IMPACTS TO SURFACE WATER FLOW AND STORMWATER QUALITY

The proposed North-South section of the Red Hill Creek Expressway and Q.E.W. Interchanges (Project) would be expected to impact the surface water flow and stormwater quality of the Red Hill Creek in three primary ways:

(i) Physical presence of the expressway and associated bridges and ramps within the valley, which alter the topography and hence the flow hydraulics of the valley and watercourse.

(ii) Inputs of additional runoff and pollutants to the Red Hill Creek through washoff from the expressway and interchange during storm events.

(iii) Disturbance impacts during construction, outside of the ultimate expressway corridor, required for construction or mitigation.

In accordance with the *Proposed Assessment Process* (ref. *Red Hill Creek Expressway North-South Section Proposed Assessment Process,* Regional Municipality of Hamilton-Wentworth, February 1996) a set of impact assessment indicators has been established which have been used to assess the impacts of the Project on Surface Water flow (quantity) and Stormwater Quality factors. The change in each of these indicators has been evaluated according to specific measures (units) for quantifying impacts of the project. These measures have also been used to evaluate the effectiveness of proposed mitigation works. Table 5.1 provides a summary of the evaluation indicators, measures, and rationale for the selection of these indicators for the assessment of Project impacts.

TABLE 5.1
RED HILL CREEK EXPRESSWAY (NORTH-SOUTH SECTION) AND Q.E.W. INTERCHANGES
IMPACT ASSESSMENT PREDICTION CRITERIA

Assessment Category	Factor	Impact Type		Indicators	Measures	Rationale
Natural Environment	Surface Water	Direct/Indirect	Post Construction	A. Estimated change in flood levels (metres above sea level) during Regulatory storm events at major road and rail crossings (i.e. CNR, Barton, Queenston, King and TH&B)	Geodetic Elev.	Changes in flood levels may affect: • safe use of infrastructure such as bridges culverts and storm sewer outlets (direct) • use of valley for recreational activities during and after storm events The absolute amount of change in flood level will vary depending on location within the valley and the storm severity Regulatory flood levels have been documented as they are typically used to define risk to public safety, and design for infrastructure such as bridges and culverts
				B. Estimated change in overall flood storage volume (m^3) from CNR to upstream of TH&B.	m^3	Changes in flood storage volume may alter the ability of the valley to convey floods which may impact downstream peak flows and upstream flood levels
				C. Estimated change in channel/flood plain velocity (average and peak in m/s) from CNR to TH&B for annual, 10 year and 100 year storm events	m/s	Changes in channel and flood plain flow velocity may impact the rate of erosion of the stream channel and floodplain, potentially impacting infrastructure and terrestrial resources. The assessment of annual (1 year), 10 year and 100 year storm events provides an indication of changes across the range of "erosion producing" conditions
		Direct	Post-Construction	D. Estimated change in infrastructure design flow rates and Regulatory flow rates (m^3/s) between CNR and upstream of TH&B	m^3/s	Changes to design flow rates affects flooding and erosion potential. The reach of Red Hill Creek between the CNR to upstream of TH&B contains all of the major road, rail crossings, and other infrastructure, which may be impacted by changes to flow rates.
				E. Estimated change in overall runoff volume (m^3)	m^3	Changes to runoff volume may impact in-stream channel erosion potential due to reduced local infiltration from development. Assessment of this change on an average annual basis provides an indication the amount of change for a wide range of rainfall events
	Water Quality	Direct /Indirect	Post-Construction	A. Primary pollutants associated with construction and operation of an expressway include: • Suspended Sediment • Biochemical Oxygen Demand (BOD_5) • Copper • Zinc • Faecal Coliforms • Polycyclic Aromatic Hydrocarbons (PAH) • Phosphorus	Mean Concentrations/Annual Loading (kg/yr)	In stream water quality, expressed either as a mean concentration or an annual load, is an important measure as it provides an indication of potential impacts to the aquatic habitat. The loading and accumulation of various pollutants, such as sediment, would be considered as "direct" impact, while the impact on aquatic habitat, such as bio-diversity would be considered an "indirect" impact.

5.1 Surface Water Impacts

Impacts to surface water flow can be categorized in terms of impacts relating to flood and erosion potential (local and in-stream), as well as changes to baseflow (low flow) conditions. The assessment of impacts due to the project on baseflow conditions and in-stream erosion are discussed in detail in separate impact assessment reports (ref. Hydrogeology and Stream Morphology Technical reporting).

5.1.1 Hydrologic Impact Assessment Methodology

The HSP-F hydrology model of watershed produced as part of the Watershed Plan has been used to assess impacts and mitigation opportunities relating to surface water flow.

Flood Control (Watershed)

A primary focus of the hydrologic analysis for the Red Hill Creek Expressway and Q.E.W. Interchanges, has been the assessment and recommendation of a program of flood control facilities to reduce peak flow rates in the downstream reach of the Red Hill Creek, in order to address existing flood potential at the Q.E.W. and future flood potential of the Expressway.

Previous analysis, confirmed by current assessment, indicates that optimal stormwater quantity control would be provided to the Q.E.W. and proposed Red Hill Creek Expressway through implementation of the existing Dartnall Road facility and two additional flood control facilities, one at Greenhill Avenue (just downstream of the Greenhill Combined Sewer Outfall) and one at Davis Creek (proposed at the existing Mount Albion/King Street access).

As flood control facilities are a necessary component of flood protection for both the proposed Red Hill Creek Expressway and Q.E.W., hydraulic assessment of the Q.E.W. - Red Hill Creek Expressway interchange, and Q.E.W.-Burlington Street interchanges has been completed on the basis of stormwater quantity control facilities being in-place (ref. Figure 1).

The hydrologic impacts of the expressway and each optional interchange layout (i.e. Burlington Street Interchange Options A, B, C and C-1) (ref. Figure 2-5) have been predicted using flow based on a the HSP-F computer model of the watershed, which has been used to simulate runoff based on a range of "design" and historical storm events:

- Existing conditions (1997/98) flow rates have been based on future (approved) land use in the watershed without the proposed expressway-specific stormwater management (flood control) facilities in-place.

- Future (expressway) condition flow rates have been based on future (approved) land use in the watershed with the proposed expressway and the proposed expressway-specific stormwater management (flood control) facilities in-place.

Expressway Impacts

In order to define hydrologic impacts of the proposed North-South Expressway on peak flow rates within the Red Hill Creek, an event based hydrologic assessment has been undertaken using the HSP-F simulation model. The assessment has been based on an historical storm event.

The historical storm approach is premised on a "Scaled storm analysis" whereby a design rainfall event is created which that simulates the watershed flow rate response determined through continuous simulation and frequency analysis. To this end, a number of historic storms have been evaluated using the HSP-F simulation model (executed in event mode) and the resulting nodal flow rates compared to the results of the continuous simulation/frequency analysis. The rainfall ordinates of each storm have then been altered (i.e. scaled) to produce a flow rate response similar the 100 year flow rate throughout the main branch Red Hill Creek. An optimal scaling factor has been established for each storm; the storm events were then compared to select the storm which best "fits" the flow rates generated through the continuous simulation/frequency analysis. In this assessment, five historic storm events have been assessed for use in discrete simulations, including:

- August 22, 1968
- September 19, 1976
- September 11, 1978
- August 30, 1981
- August 24, 1982

As part of the "flow fitting" process, the Albion Falls location (HSP-F Node 10.160) has been used as the calibration point, essentially due to its mid-point location in the watershed. Understandably, locations upstream and downstream of Albion Falls would have peak flow rates higher and lower than the continuous approach depending on location.

The 2 and 100 year return period SCS Type II (24 hour duration) storm events have also been evaluated. The results of the analysis are summarized in Table 5.2.

TABLE 5.2

DISCRETE STORM EVENT HSPF SIMULATION FOR THE RED HILL CREEK WATERSHED
(includes Dartnall Road Facility)

Node	Historical Storm Events (100 Year Scaled) Peak Flows (m^3/s)					Design Storm Events Peak Flows (m^3/s)		Frequency Analysis (Cont. Simulation) Peak Flows (m^3/s)	
	Rainfall Depth (mm)					24 Hour SCS Type II			
	71.17	99.86	76.11	67.2	111.36	Frequency (Years)		Frequency (Years)	
	Aug. 22, 1968	Sep. 17, 1976	Sep. 11, 1978	Aug. 30, 1981	Aug 24, 1982	2	100	2	100
10.010	111.36	134.95	116.89	122.99	174.84	44.96	173.35	39.8	162
10.020	125.50	145.43	130.33	135.57	173.90	53.14	190.36		
10.030	125.07	145.21	129.97	134.94	173.84	52.76	190.64		
10.040	124.58	143.79	128.85	135.52	171.89	53.57	189.73	46	152
10.041	135.59	149.52	138.54	145.69	173.28	57.25	200.55		
10.050	135.34	149.11	138.25	145.49	172.48	57.17	200.06		
10.060	1.52	1.42	1.78	1.84	1.55	0.90	2.43		
10.070	138.01	149.55	141.47	149.70	165.87	59.56	205.60		
10.080	139.82	148.85	141.35	151.09	164.53	59.63	204.67		
10.090	144.23	152.98	147.90	158.87	165.83	66.25	214.66	52	149
10.100	155.32	157.48	158.30	173.84	168.91	73.13	234.48		
10.110	152.93	156.62	157.26	174.86	168.19	73.09	241.92		
10.111	158.56	156.21	155.79	170.27	167.11	72.58	237.93		
10.120	120.09	122.05	122.00	136.96	129.64	58.23	183.23	43	118
10.141	122.39	114.75	119.38	146.49	118.70	63.39	201.63		
10.150	50.93	53.56	51.32	51.74	59.11	21.36	68.98	19.1	55.3
10.160	49.40	48.82	48.79	49.58	49.09	21.32	65.76	18.8	48.3
10.170	46.03	43.09	44.50	44.58	42.05	17.43	61.53	14.7	41.7
21.010	5.30	5.12	6.35	6.81	6.24	2.29	9.86	1.78	5.22
22.010	27.24	27.03	26.51	28.26	30.92	11.78	40.26	9.02	24.9
22.050	21.10	19.20	22.99	23.39	19.03	10.58	32.77	6.88	17
30.010	6.52	6.80	6.51	6.62	7.98	4.93	7.24	4.8	7.21
30.011	38.72	33.96	42.47	42.83	35.57	20.95	57.56	12.7	27.9
40.011	95.72	79.46	91.89	94.79	80.85	48.68	148.19	30.4	59.8

Upon reviewing the results of the impact assessment, it has been determined that the most appropriate event for discrete simulations would be the September 17, 1976 (100 year scaled) event.

Using the September 17, 1976 "scaled" design storm event, an assessment of the hydrologic impacts of the proposed North-South Expressway has been undertaken. HSP-F model parameter changes to assess expressway impacts have essentially consisted of increasing the impervious fraction of each subcatchment to represent the currently proposed Expressway design (Mud Street to Brampton Street). The impervious coverage used in the assessment is summarized in Table 5.3 (ref. Red Hill Creek Expressway North South Section, Executive Summary, Regional Municipality of Hamilton-Wentworth, June, 1998, for illustrations of expressway locations).

TABLE 5.3

SUMMARY OF EXPRESSWAY IMPERVIOUS COVERAGE

HSP-F Sub-catchment Number	Expressway Impervious Coverage (ha)
1001	1.36
1003	1.76
1004	1.96
1005	1.78
1007	0.72
1008	2.80
1009	2.06
1010	0.92
1011	0.72
1012	1.21
1013	1.21
1014	1.81
1015	6.79
1016	1.00
1022	1.46
2001	0.38
2102	6.28
3001	1.45
Total	**36.66**

The impervious coverage assumption does not include the potential "ultimate" configuration of the expressway (i.e. additional 20% pavement area). However, impervious areas have been modelled as being 100% directly connected including shoulders, which would add a conservative element to the analysis.

The results of the scaled storm analysis for the Expressway impact assessment are provided in Section 5.1.3.

5.1.2 Hydraulic Impact Assessment Methodology

Hydraulic models (HEC-2 and HEC-RAS) have been used to determine the flood levels along the Red Hill Creek Expressway, as well as at the Q.E.W. interchanges. This model has also been used to assess the benefits of various mitigation strategies. Predicted flood levels have been based on minimum culvert and bridge sizes required for flood conveyance to regulatory standards. Increases in culvert/bridge culvert sizing required to mitigate impacts on stream forming processes, terrestrial resources and recreation access have not been modeled, however any such increases in hydraulic opening size would reduce flood levels and channel velocities at bridge crossings.

Key hydraulic assessment assumptions include:

Red Hill Creek Expressway (Mud Street to Brampton Street)

- Hydraulic analysis has been undertaken based on the premise that the recommended stormwater management quantity (flood control) storage would be in-place (ref. Section 5.1.1).

- Hydraulic assessment of proposed conditions includes the proposed creek realignment. The channel/floodplain configuration has been based on an 8 m wide bankfull flow channel, 1.0 m deep, as well maintaining a minimum flood plain width of 30 to 45 m (ref. Figure 1).

Q.E.W. (Burlington Street to Highway 20)

- Hydraulic performance and flood protection achieved, has been based on a target flood level ("zero freeboard") elevation at the low point of the existing Q.E.W.. Specifically, the target flood level has been estimated to be 76.75 m (edge of travelled right-of-way) corresponding to a low point (centre line elevation) of 76.9 m at hydraulic model section 1+150 corresponding to Q.E.W. station 20+050 (ref. Figures 2-5).

- 100 year flood protection has been adopted as the ultimate flood protection target for the Q.E.W. as a 400 series highway. Final confirmation of how this flood protection standard can be attained would be subject to detailed assessment of the supplemental measures required to achieve such performance (i.e. modifications to the existing Q.E.W. culvert connection to Van Wagner's Marsh, or increasing the ramp elevation along the south limit of the Q.E.W.), including compatibility with terrestrial and fisheries protection objectives.

- 3:1 side slopes have been assumed for fills where new ramps encroach on the flood plain, or vertical retaining walls where indicated (ref. Figures 2-5)

- The long term average water level in Hamilton Harbour has been used as the starting water surface for hydraulic computations (except for the Regional Storm flood level, which has been based on a conservative "high" water level of 76.0 m in Hamilton Harbour).

- Assessment of hydraulic performance does not include potential impact of new highway barriers (New Jersey Barrier/Tall Walls etc.) associated with new ramps or collector lanes on Q.E.W. Hydraulic impacts of the existing "New Jersey" barriers have however been included.

- Assessment of hydraulic impacts of Interchange options has been based on the assumption that, as a minimum the hydraulic capacity of the existing Burlington Street bridge structure would be maintained (ref. Figures 2-5).

5.1.3 Results (Hydrology and Hydraulics)

Results of the hydraulic analysis include impacts on:

- design flow rates
- runoff volume
- flood levels
- flood storage
- channel/floodplain velocities

The results are presented separately for the two sections of the project:

- Q.E.W. (Highway 20 – Burlington Street)
- Red Hill Creek Expressway (Mud Street – Brampton Street)

Red Hill Creek Expressway (Mud Street to Brampton Street)

The assessment of changes to in-stream peak flow rates has been based on hydrologic analysis of the scaled 100 year storm event, as outlined in Section 5.1.1. The analysis has included the operation of the Dartnall Road Flood Control Facility under existing and with expressway conditions.

TABLE 5.4

PEAK FLOW SUMMARY
SCALED STORM EVENT HSP-F SIMULATION
FOR THE RED HILL CREEK WATERSHED

Historical Storm Event (100 Year Scaled) Peak Flows (m^3/s) September 17, 1976 Scaled Storm (99.86 mm)					
Node	Existing Land Use (without Dartnall Facility in-place)	Existing Land Use (with Dartnall Facility in-place)		Existing Land Use With Expressway (Dartnall Facility in-place)	
	Peak Flows (m^3/s)	Peak Flows (m^3/s)	% Change from Existing	Peak Flows (m^3/s)	% Change from Existing
10.010	156.19	137.60	-12	138.56	-11
10.020	168.33	148.51	-12	149.56	-11
10.030	168.36	148.20	-12	149.25	-11
10.040	167.27	146.45	-12	147.50	-12
10.041	172.73	153.13	-11	154.21	-11
10.050	172.33	152.54	-11	153.61	-11
10.070	172.18	151.20	-12	152.69	-11
10.080	171.49	150.09	-12	151.16	-11
10.090	174.00	153.94	-12	155.61	-11
10.100	178.40	157.38	-12	159.11	-11
10.110	180.18	156.61	-13	159.17	-12
10.111	178.32	156.24	-12	156.77	-12
10.120	145.25	122.05	-16	124.01	-15
10.130	138.73	117.51	-15	118.25	-15
10.140	137.10	115.67	-16	117.46	-14
10.141	135.25	114.75	-15	115.09	-15
10.150	79.59	53.56	-33	52.94	-33
10.151	83.64	54.41	-35	53.97	-35
10.160	78.05	48.82	-37	48.38	-38
10.161	79.24	49.38	-38	48.90	-38
30.010	36.66	6.80	-81	6.81	-81

Existing Conditions: Refers to and creek/flood plain configuration (future land use flows with approved stormwater management facilities in place)

The foregoing indicates that Expressway impacts on peak flows would be entirely mitigated by the existing stormwater management facility at Dartnall Road, exclusive of any other "approved" or "considered" stormwater management facilities.

Table 5.5 suggests that on a watershed scale the volumetric increase in runoff would be minimal (1.1% +/-).

TABLE 5.5

ANNUAL STORMWATER RUNOFF VOLUME (m

Existing Expressway Corridor	Proposed Expressway Corridor	Remainder of Red Hill Creek Watershed	Net Difference (%) in Watershed (instream) runoff volume)
35,000	232,000	21,000,000	+1.1

The minor increase in runoff volume would be offset by the capture and storage of stormwater runoff in stormwater quality and erosion control facilities. The volume detained in these facilities would be released over the 24-48 hours following storm events hence there would be essentially no adverse impact on hydrologic processes

Changes in flood storage have been calculated using the hydraulic model which conservatively includes the maximum flood storage throughout the creek system including storage upstream of road crossings. Table 5.6 provides a summary of changes in flood storage for both mitigated and unmitigated conditions.

TABLE 5.6

IMPACT PREDICTION AND MITIGATION
RED HILL CREEK EXPRESSWAY: BRAMPTON STREET TO MUD STREET

SURFACE WATER
FLOOD STORAGE FOR REGULATORY FLOOD EVENTS
(m^3)[1]

Location	Existing Conditions[1]		Proposed Expressway [2]	
	100 Year Storm	Regional Storm	100 Year Storm	Regional Storm
Red Hill Creek from Brampton Street to upstream of TH&B	2,000,000	4,100,000	1,240,000 [3]	3,150,000

1. Flood storage based on Future Land Use flow rates (with Dartnall Road Stormwater Management and "Approved" Stormwater Management Facilities In-Place)
2. Flood storage based on Future land use flow as in 1. (above) with additional expressway stormwater management facilities (flood control) in place
3. Includes +290,000m^3 in stormwater management storage at Davis Creek (Site 7-A)

Changes in channel and flood plain velocities have been calculated for the Red Hill Creek Expressway based on average cross-sectional velocities calculated using the hydraulic model throughout each reach of the Red Hill Creek. Table 5.7 provides a summary of average channel and flood plain velocities under existing and proposed conditions.

Figure 6 illustrates the effects of the proposed Expressway on channel and floodplain velocities.

TABLE 5.7

IMPACT PREDICTION AND MITIGATION
RED HILL CREEK EXPRESSWAY: BRAMPTON STREET TO MUD STREET

Surface Water, Stream Channel And Flood Plain Velocities

Location	Return Period (Years)	Flow Range (m^3/s)		Channel and Flood Plain Velocities (m/s)					
				Existing			Proposed		
		Existing	Proposed	Channel	Flood Plain	Mean	Channel	Flood Plain	Mean
From 700 m d/s of CNR to 700 m u/s of TH&B	1	16 - 20	20 - 28	1.63	0.09	1.61	1 8	0.30	1 29
	10	78 - 105	54 - 70	1.71	0.15	1.30	2.33	0.46	1 50
	100	122 - 172	75 - 101	1.98	0.21	1.30	2.48	0.47	1.56

Existing: Refers to existing creek channel and floodplain configuration based on future land use flows
Proposed: Refers to realigned creek channel with expressway, flows based on future land use with expressway stormwater management (flood control) in place

Stream flow velocity typically increase as due to the improved hydraulic performance of the Red Hill Creek would be mitigated primarily through the implementation of the re-designed of the Red Hill Creek (ref. Stream Morphology/Stream Stability Report). The channel and floodplain configuration of the proposed Red Hill Creek has been designed be compatible with the proposed expressway.

Predicted flood levels contained in this Table have been based on minimum culvert and bridge sizes required for flood conveyance to regulatory standards. Increases in culvert/bridge culvert sizing required to mitigate impacts on stream forming processes, terrestrial resources and recreation access have not been modeled to date, however any such increases in hydraulic opening size would reduce flood levels and channel velocities at bridge crossings.

Table 5.8 provides a summary of existing and proposed (with expressway) flood levels. Figures 7 and 8 illustrate the change in 100 year and Regional flood levels.

TABLE 5.8

IMPACT PREDICTION AND MITIGATION
RED HILL CREEK EXPRESSWAY: BRAMPTON STREET TO MUD STREET

Surface Water Flood Levels (m)

Location	Flood Event Return Period (years)			
	100		Regional	
	Existing Conditions	Proposed Conditions	Existing Conditions	Proposed Conditions
CNR	84.0	78.6	85.4	83.7
Barton Street	84.0	80.1	85.6	88.7
Queenston	84.7	84.8	87.5	88.5
King Street	88.7	88.0	93.9	94.3
TH&B	92.7	91.8	97.7	96.7
SWM Site 4 (Greenhill)	95.9	99.0	98.2	100.70
SWM Site 7-A (Davis Creek)	91.2	96.6	95.4	97.75

Existing Conditions: Refers to existing valley and creek configuration (future land use flows with approved stormwater management facilities in place)

Proposed Conditions: Refers to proposed valley/creek configuration with expressway in place (future land use flows with approved stormwater management facilities in place plus expressway (flood control stormwater management in place)

Implementation of the proposed surface water quantity mitigation measures would typically reduce 100 year and Regional storm event flood levels throughout majority of the Red Hill Creek. This is primarily due to the provision of larger bridge openings, hence improved hydraulics, and is also due to the proposed flood control facilities at Sites 1 (Dartnall), 4 (Greenhill) and 7A (Davis Creek) which reduce peak flow rates in the downstream reaches of the Red Hill Creek.

Slight increases in flood levels would occur at locations where the flood plain would be constricted (i.e. Queenston Road). 100 year and Regional flood levels would also increase at stormwater quantity management facility locations (i.e. Greenhill - Site 4, and Davis Creek - Site 7A).

The proposed mitigation measures would provide flood protection to the Red Hill Creek Expressway up to 100 year storm conditions with potential minor violation of freeboard/clearance standards. Providing flood protection to the 100 year storm event standard as is proposed (through upstream flood control storage) is significant with respect to public safety and meeting flood protection standards for new roads.

The Expressway would remain susceptible to flooding and damage under Regional storm event. Although the remaining potential for flood damage under Regional storm event conditions would have low probability of occurrence, damage to the expressway may be significant during such an event. Potential for flood damage under Regional Storm conditions is common to many public roadways which cross or are located adjacent to watercourses. Primary mitigation for Regional Storm event would include a flood contingency plan to allow co-ordinated closure and evacuation of the expressway under Regional Storm conditions.

Q.E.W. (Burlington Street to Highway 20)

Hydrologic impacts of this section of the expressway have not been modelled explicitly using the HSP-F model. Notwithstanding, due to the location of this section at the outlet of the Red Hill Creek watershed, changes in in-stream peak flow rates due to additional impervious area would be negligible, and may actually result in a marginal reduction in peak in-stream flow rates. This effect is a well documented hydrologic response, which results from increased efficiency of local runoff, affecting the timing of flow response, essentially allowing the conveyance of streamflow from these downstream areas to Hamilton Harbour, prior to arrival of the peak flow from the upper watershed.

Similarly, the change in storm runoff volume has also not been explicitly modelled for this section of the project; however, based on the hydrologic analysis completed for the upper section of the Red Hill Creek watershed, increases in annual runoff volume from this section of the project would be expected to be less than 0.3% of total watershed response.

Table 5.9 provides a summary of 100 year and Regional flood elevations at the Q.E.W. for the various Burlington Street Interchange options (ref. Figures 2-5):

TABLE 5.9

SURFACE WATER
FLOOD LEVELS (m) AT Q.E.W. AT LOW POINT
[HYDRAULIC MODEL STATION 1+150 - Q.E.W. STATION 20+050]

Flood Event Return Period (years)			
100 Year Event			
Existing Flood Plain Configuration without Proposed Expressway Stormwater Quantity Management (i.e. Dartnall in-place only)	**Existing Flood Plain Configuration with Proposed Expressway Stormwater Quantity Management (i.e. Dartnall ,Greenhill and Davis in-place)**	**Option A/B with Proposed Expressway Stormwater Quantity Management (i.e. Dartnall ,Greenhill and Davis in-place) and no local mitigation**	**Option C/C-1 with Proposed Expressway Stormwater Quantity Management (i.e. Dartnall ,Greenhill and Davis in-place) and no local mitigation**
77.37	77.06	77.06	77.08
Regional Storm			
77.85	77.85	77.86	77.87

Changes in flood storage have been calculated using the hydraulic model which conservatively includes the maximum flood storage throughout the creek system, including storage upstream of

road crossings. Table 5.10 provides a summary of changes in flood storage for both mitigated and unmitigated conditions.

TABLE 5.10

IMPACT PREDICTION AND MITIGATION
Q.E.W. (BURLINGTON STREET TO HIGHWAY 20)
SURFACE WATER
STREAM CHANNEL AND FLOOD PLAIN VELOCITIES

Location	Existing Conditions	Option A/B (with flood plain excavation)	Option C (no mitigation)	Option C-1 (no mitigation)	Option C-1 (mitigation) [2]
Red Hill Creek from Outlet at Windermere Basin to Brampton Street	770,000	802,000 (+4.2 %)	743,000 (-3.5%)	757, 000 (-.0.4%)	775,000 - 810,000 (+0.6% to +5.2%)

1. Flood storage to point of overtopping of Q.E.W.
2. Type and form of mitigation varies – ref. Section 6.

Changes in channel and flood plain velocities have been calculated based on average cross-sectional velocities calculated using the hydraulic model throughout each reach of the Red Hill Creek. Table 5.11 provides a summary of average channel and flood plain velocities under existing conditions as well as each of Q.E.W. - Red Hill Creek Expressway and Q.E.W. - Burlington Street interchange options.

TABLE 5.11

IMPACT PREDICTION AND MITIGATION
Q.E.W. (HIGHWAY 20 TO BURLINGTON STREET)
SURFACE WATER
STREAM CHANNEL AND FLOOD PLAIN VELOCITIES

Location	Return Period (Years)	Flow Range (m^3/s)		Channel and Flood Plain Velocities (m/s)					
				Existing		Proposed			
						Option A with no mitigation		Option C and C-1 with no mitigation	
		Existing	Proposed	Channel	Flood Plain	Channel	Flood Plain	Channel	Flood Plain
Q.E.W. from Outlet at Windermere Basin to Brampton Street	1	19 - 21	19 - 22	0.57	0.06	No change		0.58	0.05
	10	96 - 100	70	1.46	0.19	No change		1.21	0.16
	100	171 - 174	101 - 105	1.90	0.30	No change		1.51	0.21

Existing Conditions: Refers to and creek/flood plain configuration (future land use flows with approved stormwater management facilities in place)

Proposed Conditions (Options A and C, C-1): Refers to modified creek/flood plain configuration with expressway/ramps in place for each option (future land use flows with approved stormwater management facilities in place plus expressway (flood control stormwater management in place)

5.2 Stormwater Quality Impacts

The source of in-stream water quality impairment within the Red Hill Creek is to a large extent, due to inputs from the surrounding subwatersheds, rather than from sources within the Red Hill Creek valley. Notwithstanding, highway runoff typically contains suspended sediments, heavy metals, nutrients, hydrocarbons and polycyclic aromatic hydrocarbons (PAH's), de-icing agents as well as bacteria and other pollutants. Therefore runoff from the North-South Expressway and Q.E.W. Interchanges would be expected to exhibit a higher concentration of these pollutants than the current open space land use within the Red Hill Creek Valley and other open space areas. Pollutant loading from highways is derived from the following sources (Barrett et al, 1993):

- Vehicle Inputs
  - direct vehicles inputs (emissions and frictional parts wear)
  - indirect vehicle inputs (particles which accumulate on vehicle and are washed off, often during storm events)
- Atmospheric Deposition
  - dustfall (airborne particles deposited on highway during dry weather)
  - precipitation (airborne particles within rainfall)

In addition, the type of drainage system utilized in the highway design can also effect pollutant contributions. The total pollutant loading from the Red Hill Creek Expressway and Q.E.W. Interchanges would therefore be dependant on a number of factors including: traffic volume, highway drainage system design, and precipitation characteristics.

On a watershed scale, the additional loading to the Red Hill Creek would also be dependant on these factors. Reduced traffic volumes on other surrounding roadways (due to the expressway) may partially offset increased pollutant loadings from the North-South Expressway, however at this time, it is difficult to quantify this effect. [Note: Current research of pollutant deposition processes suggests that pollutant loading is not only related to traffic volume but also significantly dependant on other factors such as surrounding land use and inter-precipitation periods (Stotz, 1987, Mar et al, 1982 in Barrett et al, 1993)]. For the purpose of this assessment, any potential reduction in pollutant loading from existing developed areas has not been included, thereby providing a conservative approach to assessment of expressway and interchange impacts.

5.2.1 Methodology

The primary means of assessing expressway impacts on stormwater quality due to pollutant loading has been through the use of a "Mass Balance" modeling approach as outlined in the following sections.

5.2.2 Mass Balance Modelling

The base mass balance model prepared as part of the Red Hill Creek Watershed Plan has been used to predict impacts of the project. A full description of the methodology for the model is contained in the technical reports completed as part of the Red Hill Watershed Plan (ref. Appendix A of *Opportunities for Management of Stormwater (Quality and Quantity), Streams and Groundwater,* Philips Planning and Engineering Limited January 1998 *and Red Hill Creek Water Quality Report,* Philips Planning and Engineering Limited, August, 1997).

In summary, the water quality mass balance modelling for the Red Hill Creek watershed provides:

- characterization of the pollutant loading contributions to the Red Hill Creek from various point and non-point sources within the watershed,
- a method for assessment of water quality changes due to land use changes within the Red Hill Creek Watershed, including the North-South Expressway and Q.E.W. Interchanges, and urban development
- a method to evaluate the effectiveness of potential best management practices (BMPs), such as stormwater water quality constructed wetland and wetponds, and CSO remediation, which may be implemented to mitigate the impacts of land use changes on water quality.

Calculations of pollutant loading due to the Red Hill Creek Expressway (North-South section) and Q.E.W. Interchanges were obtained by modifying the existing land use, base model to reflect changes in land use, hence, hydrologic response, as well as changes to Event Mean Concentrations (EMC's) for various contaminants to reflect pollutant contributions from the proposed highway surfaces.

Land Use Changes

Construction of the Red Hill Creek Expressway and Q.E.W. Interchanges will occur mainly in the lower subcatchment areas of the watershed. The analysis is based on land use changes as follows:

- 7 to 9 hectares of additional pavement area (roadway and shoulders) within the area of the Q.E.W. Interchange (Burlington Street to Highway 20). Three optional interchange alignments at Burlington Street have been assessed (Options A, B, C and C-1) with Option C and C-1 resulting in the greatest increase in pavement area (ref. Figures 2 - 5)

- up to 45 hectares of additional pavement area based on potential ultimate (roadway and shoulders area) for the Red Hill Creek Expressway in the area between Brampton Street and Mud Street (ref. Figures 2 and 6).

The expressway would, for the most part, replace existing open space and park areas, resulting in a net increase in impervious area to the overall watershed.

The assessment documented herein provides a comparison of pollutant loadings from the Red Hill Creek Watershed under existing land use conditions (6050 ha - 30%+/- impervious), and the proposed North-South Expressway up to (54 ha+/-) paved area including the Q.E.W. Interchanges. The Project represents approximately 0.8% of the total watershed area, however, due to the highly impervious nature of the project (i.e. 100% of 54 ha), the project area would represent approximately 2.9% of the total impervious area within the watershed.

It should be noted that the entire length of the Expressway has been included in the mass balance model, whereas the mass balance model only encompasses the area of the watershed upstream of Queenston Road. Hence the predicted pollutant loading, relative to the existing condition, would be considered conservative (i.e. overstates the impacts) and ensures that predicted impacts of the full length of the expressway are accounted for.

Event Mean Concentrations (EMC)

The base model has been modified to incorporate annual pollutant loadings from the expressway for the following primary parameters associated with highway runoff:

- Polycyclic Aromatic Hydrocarbons (PAH)
- Total suspended Solids (TSS)
- Total Phosphorus (TP)
- Zinc
- Biological Oxygen Demand (BOD_5)
- Copper (Cu)
- Fecal Coliform (F. Col.)

Event mean concentrations for highway runoff have been abstracted from various literature sources. EMCs for heavy metals and PAHs were taken directly from "Heavy Metals and PAHs in Highway Bridge Runoff," (Marsalek *et al.*, 1997). This data has been particularly relevant as the study focussed on highway loading within the same geographic area and climate conditions as the North-South Expressway. Nutrients, TSS and coliform EMCs were obtained by averaging values from a number of sources (Wanielista, 1993; Maltby *et al.* 1995). Table 5.12 summarizes the EMC values used in the mass balance model for highway runoff.

TABLE 5.12 EVENT MEAN CONCENTRATIONS (EMC) USED FOR HIGHWAY IMPACT ASSESSMENT		
Parameter	**Event Mean Concentration (EMC)**	**Unit**
BOD_5	24	mg/L
Copper (Cu)	136	ug/L
Faecal Coliform (F.C.)	1000	counts/100 ml
PAH	2.3	ug/L
Total Phosphorus (TP)	0.4	mg/L
Total Suspended Solids (TSS)	150	mg/L
Zinc	337	ug/L

5.2.3 Results

Table 5.13 provides a summary of annual pollutant loading (without mitigation) due to the proposed Project.

TABLE 5.13 SUMMARY OF PREDICTED ANNUAL POLLUTANT LOADING (KG/YR)					
Parameter	**Annual Pollutant Loading (kg/yr)**				**Change In Pollutant Loading (%)**
	Land Use				
	Existing Land Use [2&3]	**Existing Land Use with Expressway**			
		Additional Loading due to Q.E.W. Interchanges (Option C)	**Additional Loading due to Expressway Brampton Street to Mud St.**	**Total Loading including Expressway**	
BOD_5	1 264 346	1325	6401	1 272 072	6.1
Cu	371	7	36	414	11.6
F.C. [1]	5.04×10^{15}	5.04×10^{15}	0.002×10^{15}	5.042×10^{15}	0.04
PAH	17.33	0.13	0.62	18.08	4.3
TP	4328	22	102	4452	2.9
TSS	2 089 769	8284	36 474	2 134 527	2.1
Zinc	2813	19	90	2922	3.8

1. Units for F.Coliforms Counts/100 mL
2. Existing land use includes stormflow, baseflow and CSO contributions for watershed area upstream of Queenston Road only
3. Includes current expressway corridor as open space

Based on Table 5.13, it is clear that the primary water quality impacts of the project would be related to increases in PAH and Metals, as well as increases in BOD_5. Significant increases in Copper (Cu) loading have been predicted. This predicted impacted is due in part to the use of a significantly higher EMC value for copper for highway loading based on current research (Marsalek et al. 1997), as compared to EMC values for other urban land uses adopted in the Mass Balance Model for the watershed.

5.2.4 Construction Impacts on Stormwater Quality

Construction of the expressway and watercourse re-alignment works would result in an increase in wash-off of sediment, due to the removal of vegetative cover and exposure of subsoils to the erosive effects of rainfall and runoff. Typically the amount of sediment that washes off, on a storm by storm basis, is highly variable and is influenced by a large number of factors including:

- total amount and distribution of rainfall
- peak rainfall intensity
- soil type
- slope
- seasonal affects (vegetation, surface condition)
- type of construction activity (i.e. cut vs fill)
- construction phase

Due to the highly variable nature of these factors, which change through the season and with the construction progress, It is difficult to precisely predict the impact of construction on peak in-stream sediment concentrations. A literature review relating to sediment wash-off during construction reflects this through a wide range in results:

- Wolman (1975) found that sediment yield from sites under construction may increase by 5 to several hundred times greater than fully vegetated conditions
- Vice (1967) found that storm event sediment yields during construction were on average 10 greater than for agricultural areas and 200 times greater than pre-construction levels for grassland areas
- Schueler and Lugbill (1990) found that median suspended sediment concentrations in runoff from constructions sites (with no Erosion and Sediment Controls) were as high as 4145 mg/L (i.e. 165 time higher than the pre-development concentration of 25 mg/L). This study also found that implementation of Erosion and Sediment Controls would reduce median suspended sediment concentrations to approximately 283 mg/L (i.e. 14 fold reduction over sites with no sediment and erosion controls)

The foregoing results indicate that although construction may significantly increase potential for sediment wash-off, implementation of Erosion and Sediment controls, as is proposed during expressway and creek re-alignment works, can vastly reduce this potential impact.

A preliminary estimate of the potential for soil loss (assuming no sediment and erosion controls) has been undertaken based on estimates of soil erodibility completed as part of the *Environmental Assessment Submission- Supplementary Documentation (RMH-W, 1983),* as outlined in Table 5.14

TABLE 5.14
ESTIMATE OF POTENTIAL CONSTRUCTION SOIL LOSS
(WITH NO EROSION/SEDIMENT CONTROL MEASURES)
BASED ON SOIL ERODIBILITY DETERMINED AS PART OF THE ORIGINAL ENVIRONMENTAL ASSESSMENT STUDY, (1983)[1]

Station (original EA Report)	Length (m)	Typical Maximum Corridor Width (m)	Area (ha)	Unit area Sediment Generating Potential	Potential Soil Loss Rate		Potential Sediment Loss
					ton/ac/yr	kg/ha/yr	(kg/yr)
20+500 to 20+900	400	70	2.8	moderate	13	32123	89 943
20+900 to 21+300	400	70	2.8	severe	18	44477	124 537
21+300 to 21+600	300	70	2.1	slight	5	12355	25 945
21+600 to 22+000	600	70	4.2	moderate	13	32123	134 915
22+000 to 22+400	400	70	2.8	moderate	13	32123	89 943
20+400 to 22+600	200	70	1.4	slight	5	12355	17 297
22+600 to 22+800	200	70	1.4	slight	5	12355	17 297
22+800 to 23+300	500	70	3.5	very severe	25	61774	216 210
23+300 to 23+400	100	70	0.7	slight	5	12355	8 648
23+400 to 24+900	1 500	70	10.5	slight	5	12355	129 727
24+900 to 25+200	300	70	2.1	very severe	25	61774	129 726
25+200 to 26+600	1 400	70	9.8	severe	18	44477	435 874
26+600 to 27+100	500	70	3.5	severe	18	44477	155 671
27+100 to 27+300	200	70	1.4	slight	5	12355	17 297
27+300 to 27+600	300	70	2.1	slight	5	12355	25 945
27+600 to 28+200	600	70	4.2	slight	5	12355	51 890
28+200 to 28+600	400	70	2.8	moderate	13	32123	89 943
28+600 to 28+900	300	70	2.1	slight	5	12355	25 945
28+900 to 29+200	300	70	2.1	slight	5	12355	25 945
Totals	**8 900 m**		**62.3 ha**				**1,812, 000 kg/yr (1812 tonnes/yr)**

1. Includes portion of East-West (Lincoln Alexander Expressway)

Current levels of suspended sediment transport in the Red Hill Creek are approximately 4400 tonnes per year (i.e. 2100 tonnes from watershed/creek plus 2300 tonnes from the Sewage Treatment Plant - ref Water Quality Report, Philips Planning and Engineering Ltd.). Table 5.14 indicates that erosion of soil during construction of the expressway and creek realignment (assuming no protective measures were taken), could increase the total amount of sediment carried by the Red Hill Creek to Windermere Basin by up to 50% on an annual basis (based on the total suspended sediment originating in the Red Hill Creek - including contributions from the Woodward Avenue Sewage Treatment Plant). However the relative increases in suspended sediment loading would likely be lower than these upper limits given current erosion prone state of the watercourse channel which has not been explicitly accounted for in existing conditions (ref. Mass Balance Model Results - *Red Hill Creek - Watershed Plan Water Quality Report* Philips Planning and Engineering Limited, 1997). These increases would be reduced to approximately 5-10% (i.e. conservatively assuming a 5 to 10 fold reduction in sediment yield), through the implementation of standard Erosion and Sediment Control measures during construction.

Given the fact that even the best erosion and sediment control measures are not fully (i.e. 100%) effective in preventing wash-off of soils from construction sites, the potential for negative impacts on stream water quality during construction cannot be entirely eliminated, particularly if uncharacteristically large rainfall events occur during the construction period. Notwithstanding, techniques such as construction phasing, and stringent erosion and sediment controls would reduce this potential.

Increases in suspended sediment generated during construction should be placed in context with the existing condition. It should be noted that during storm events, in-stream suspended sediment concentrations are currently (ref. *Red Hill Creek, Hamilton, Ontario - Water and Sediment Quality and Affects of Fish and Fish Habitat*, Red Hill Valley Environment Rehabilitation Project, 1997) comparable to runoff from a well managed construction site, based median sediment concentrations noted by Schueler (1990). This suggests that current in-stream water quality is already poor. Some potential for negative impacts on aquatic habitats would remain, however, due to the temporary nature of the construction, impacts on suspended sediment loading to the Red Hill Creek , although potentially higher in the short term, would be minor in the longer term when creek stabilization objectives are achieved and annual suspended sediment loads are lowered.

6. MITIGATION OPPORTUNITIES

6.1 Surface Water (Flooding and Erosion)

As outlined in Section 5, the construction of the Project would impact on surface water as follows:

Red Hill Valley Section

- Loss of flood plain storage and conveyance would increase flood levels within the valley due to reduced flood routing.

- Depending on location, parts of the Expressway would be subject to flooding from storms greater than the 10 year frequency event; this would not comply with Provincial freeboard standards for such roadways.

- Construction of expressway embankment would sever local drainage features potentially causing flooding on upstream properties (riparian impact).

- Constrictions to channel and flood plain during construction would increase local flood levels and may impact construction activities during flood events.

- Construction of expressway, ramps and crossings may increase channel and flood plain velocity, increasing erosion.

- Additional runoff from impervious areas of the expressway would marginally increase design flow rates (i.e. approximately 1% for 100 year event) within the lower reaches of the Red Hill Creek.

- Locally the runoff from the expressway may increase peak flow rate in tributary swales and drainage features.

- Additional impervious areas of the expressway would marginally increase runoff volume to the Red Hill Creek.

Q.E.W. Section

- Loss of flood plain storage and constriction of flood plain would increase flood levels adjacent to the Q.E.W. Under existing design conditions the Q.E.W. is subject to flooding from storms greater than the 10 year frequency event; this does not currently comply with Provincial freeboard standards for expressways.

- Further constriction of the flood plain would increase the frequency of potential flooding.

- Constrictions to channel and flood plain during construction would increase local flood levels and may impact construction activities during flood events.

- Construction of Q.E.W. collector lanes, ramps and crossings may increase channel and flood plain velocity.

- Due to the location of the Q.E.W. and Interchanges, (i.e. near the outlet of the Red Hill Creek), the additional runoff from impervious areas of the expressway and Q.E.W. would not be expected to increase design flow rates within the lower reaches of the Red Hill Creek.

- Locally the runoff from the expressway interchanges may increase peak flow rates in tributary swales and drainage features.

- Additional impervious areas of the Q.E.W. and Interchanges would marginally increase runoff volume to the Red Hill Creek.

6.1.1 Surface Water Impact Mitigation Techniques - Screening/Assumptions

In order to mitigate these impacts, a number of stormwater quantity management techniques or options have been considered. Table 6.1 outlines the range options and screening results.

TABLE 6.1 (Continued)

SUMMARY OF STORMWATER MANAGEMENT QUANTITY CONTROL AND FLOOD CONVEYANCE IMPROVEMENT TECHNIQUES

Project Section	Technique Description	Comment and Screening Results
Q.E.W. and Red Hill Valley	Provide sufficient culvert/bridge capacity to convey flood flows	Reduces flood elevations and erosion potential • **Carried Forward**
Red Hill Creek Expressway	Use of elevated structures and retaining structures (vs. fill slopes) for sections of expressway and ramps (ref. Plan for locations)	Reduces flood elevations and loss of flood storage High cost • **Carried Forward for ramp structures and selected expressway locations**
Red Hill Creek Expressway	Refinements to expressway horizontal and vertical alignment to minimize height and extent of fill (ref. area upstream of Barton St.)	Reduces flood elevations and loss of flood storage • **Carried Forward (Barton Street to Queenston Road)**
Red Hill Creek Expressway	Utilize flow equalization culverts through expressway to connect flood plain areas	Reduces flood elevations and maximizes use of valley for flood storage • **Carried Forward**
Red Hill Creek Expressway	Provide local drainage conveyance culverts beneath expressway embankment to provide discharge to Red Hill Creek	Provides positive drainage for local watercourses • **Carried Forward**
Q.E.W. and Red Hill Valley	Minimize construction encroachment in flood plain (where possible)	• **Carried Forward as part of Environmental Management Plan**
Q.E.W. and Red Hill Valley	Develop and implement flood contingency plans during construction to evacuate construction area of personnel and equipment	• **Carried Forward as part of Environmental Management Plan**
Red Hill Expressway	Implement redesigned natural channel with flood plain (ref. Stream Morphology Impact Mitigation and Plan illustrating flood plain location)	• **Carried Forward (ref. Stream Morphology/Stability report)**

TABLE 6.1 (Continued)

SUMMARY OF STORMWATER MANAGEMENT QUANTITY CONTROL AND FLOOD CONVEYANCE IMPROVEMENT TECHNIQUES

Project Section	Technique Description	Comment and Screening Results
Q.E.W. and Red Hill Creek Expressway	Incorporate erosion and flood control storage facilities in combination with water quality treatment facilities where downstream tributaries are sensitive to erosion and flooding (ref. Plan for locations)	• **Carried Forward for expressway areas which drain to local tributaries**
Q.E.W. and Red Hill Creek Expressway	Implementation of shallow grassed swales and water quality/erosion control storage facilities to promote infiltration	Grassed Swales would be part of standard expressway drainage system • **Carried Forward**
Q.E.W. and Red Hill Creek Expressway	Upstream stormwater management quantity control facilities	Significantly reduces peak flow rates along expressway and at Q.E.W. and Expressway (primary) benefit to CNR-Queenston Section) • **Carried Forward**
Q.E.W.	Flood plain overbank excavation	Increases flood conveyance capacity by 15 - 25% • **Carried Forward (in conjunction with upstream flood storage)**
Q.E.W.	Raise Q.E.W. above 100 year flood level	Not feasible due to • Encroachment into provincially significant wetland areas • Cost/traffic disruption • Upstream hydraulic impacts • **Not Carried Forward**
Q.E.W.	Raise RHCE interchange ramp (Option C-1) above 100 year flood level	Not feasible without upstream stormwater management quantity storage due to potential for upstream hydraulic impacts at the Red Hill Creek Expressway (i.e. @ CNR), however would be feasible in conjunction with upstream stormwater management storage and potentially in conjunction with flood plain excavation. • **Carried Forward** (in conjunction with upstream flood storage a supplemental or stand-alone measure
Q.E.W.	Widening of Burlington Street Bridge	Provides nominal improvement for flood conveyance. • **Carried Forward** (in conjunction with upstream flood storage and flood plain excavation)
Q.E.W.	Alter Q.E.W. cross culvert ends to improve flood conveyance capacity between Red Hill Creek and Van Wagner's Marsh	Would function to convey storm flow to the Van Wagner's Marsh for temporary storage in the marsh, essentially shaving the peak flow rates in the in the Red Hill Creek. Would require alteration to the existing culvert openings and potential expansion of the existing culverts • **Carried Forward** (in conjunction with upstream flood storage and flood plain excavation) as a potential supplemental or stand-alone measure

6.1.2 Proposed Stormwater Management (Flood Control)

Control of stormwater quantity (flooding) is primarily focussed on control of infrequent storm events, which typically exhibit extremely high peak flow rates and runoff volumes. In the watershed context, it is necessary to control flows not from the expressway but rather from the developed and yet to be developed subwatersheds with a focus on protecting the future expressway and existing Q.E.W. Given the large volumes of flow, the primary criteria for selecting and optimizing stormwater quantity control facilities are as follows:

⇒ Sites must have large volumes of storage available; deep valleys and broad flood plains provide the most storage potential (naturally).

⇒ Sites must be located downstream of major outfalls in order to attenuate the large peak outflow from these storm sewer outfalls. Depending on the location and tributary area

draining to the outfall, the peak flow from a single outfall (such as Greenhill) under extreme storm events may result in storm flow rates which exceed the target design flows for the downstream expressway and Q.E.W.

⇒ Where multiple facilities are required they should be implemented at locations within the watershed complementary to each other. As such, facilities are ideally arranged in a parallel network (i.e. facilities on different branches) versus a series network (i.e. multiple facilities along the same branch).

⇒ Facilities must be located far enough upstream such that they function to provide flood protection to the intended location and infrastructure. It should also be understood that physical constraints, either existing or proposed (like the expressway), can restrict the attainable flood depth and hence storage volume for flood control adjacent to such infrastructure, as opposed to upstream storage locations where much greater storage depths may typically be implemented.

Red Hill Creek Expressway and Q.E.W. Interchanges Flood Storage Assessment

For the Red Hill Creek system the proposed flood storage program (i.e. Facilities at Dartnall, Greenhill and Davis Creek, ref. Figure 1) embodies all of these principles:

- facilities located downstream of major outfalls (Greenhill)
- parallel system (i.e. Greenhill and Davis)
- located in valley of significant depth and areal extent (i.e. Davis, Greenhill, and, Dartnall all would have attainable storage depths greater than 4 metres)
- located upstream of primary flood prone areas which commence at Queenston and extend downstream to CNR and ultimately the Q.E.W.

Other facility locations for quantity (flood) control have also been assessed through a number of studies by Philips Planning and Engineering Limited including :

- ❑ *Mountain East-West North-South Transportation Corridor - Drainage Study, 1989 (based on SCS 100 year Design Event)*
- ❑ *Q.E.W. - Red Hill Creek Interchange Spill Mitigation, 1996 (based on SCS 100 year Design Event)*
- ❑ *Watershed Plan - Opportunities for Management of Stormwater (Quality and Quantity) Streams and Groundwater, 1998*

Each of these studies evaluated the potential for quantity control at some or all of the seven (7) primary locations as summarized in Table 6.2.

TABLE 6.2

SUMMARY OF STORMWATER QUANTITY MANAGEMENT FACILITY SITES

Location	Storage Volume (m^3)	Description/Comment
Site No. 1	500,000	Dartnall Road just south of Stone Church Road at the Dartnall Road Interchange (completed in 1996) **Preferred site - Constructed** ⇒ Large Drainage Area ⇒ Large volume available
Site No. 2	99,000	Upper Ottawa west of the C.N.R. within the abandoned Upper Ottawa landfill site ⇒ Limited Storage volume available ⇒ Large drainage area ⇒ Potential impact on landfill stability and surrounding lands
Site No. 3	366,000	King's Forest Golf Course at the base of the escarpment within the Red Hill Creek valley ⇒ Potential major disruption to existing land use (Golf Course) and natural area ⇒ Located upstream of major outfall (Greenhill) thereby reducing effectiveness
Site No. 4	300,000 (415,000 available)	Greenhill Avenue just north of the Greenhill storm outfall within the Red Hill Creek valley **Preferred site** ⇒ Large Drainage Area ⇒ Large volume available ⇒ Located downstream of major outfall (Greenhill) thereby increasing effectiveness
Site No. 5	44,200	Mt. Albion (Davis Creek and Montgomery) just south of King Street within the tributary valley ⇒ Limited Storage volume available ⇒ Controls Davis and Montgomery Creek
Site No. 6	362,000	TH&B (Montgomery Creek) just south of the TH&B ⇒ Limited Drainage Area (Montgomery Creek only) ⇒
Site No. 7	391,000	Quigley (Davis Creek) at King Street ⇒ Controls Davis Creek Only
Site No. 7-A	297,000	Mt. Albion (Davis Creek and Montgomery Creek) just south of King Street within the tributary valley (formerly Site 5) updated storage based on new Albion Road/King Street embankment **Preferred site** ⇒ Large Drainage Area ⇒ Large storage volume available ⇒ Located downstream of confluence of Davis and Montgomery Creek which increases effectiveness

A range of facility combinations has been simulated as part of this Impact Assessment and Design Process. Based on these simulations, the preferred combination of Sites 1, 4 and 7 has been selected. The total storage provided at these sites(1,097,000 m^3) serves to reduce the 100 year peak flow rate (Future Land Use conditions) from approximately 168 m^3/s to 80 m^3/s for the design storm event analysis and from 164 m^3/s to 113 m^3/s for the historic storm analysis at Brampton Street.

Since the Opportunities Report submission, facility sizes and storage volumes have been further optimized through continuous hydrologic simulation analysis, as part of the IADP, to achieve a reduction in the peak 100 year flow rate to approximately 105-107 m^3/s [with facilities at Dartnall, Greenhill and Davis - 1, 4 and 7A - (Case 14)] at the Q.E.W. (downstream of Brampton Street).

Supplemental On-site Stormwater Quantity Control for Future Development

A qualitative screening of on-site stormwater quantity management facilities (i.e. as part of future development) to achieve the in-stream flow rates required for the Expressway and Q.E.W. has also been undertaken. The implementation of these types of facilities to address target in-stream flow rates has been informally discounted on the following basis:

The watershed is currently highly urbanized; further development within the watershed would involve less than 25% of the total watershed area (ref. *State of the Watershed Report*). In addition, in-stream flow rates under Existing Land Use conditions within the watershed currently exceed the Expressway and Q.E.W. flow rate targets. Hence, the implementation of traditional post to pre-development flow rate control would provide very little benefit in terms of meeting in-stream target flow rates. An alternative would be to require over-control of runoff from new development, however due to the limited area of future development with respect to the total watershed area (i.e. 25 %) the overall effectiveness of such control would also be limited. Further, the unit cost of runoff storage volume within new development sites would be much higher than valley facility locations, as all of the storage would need to be created through excavation. Finally, controlling runoff from new development alone would not address the significant peak flow rates generated at major outfalls such as Upper Ottawa and Greenhill, which, in the case of Greenhill alone, would exceed the in-stream 100 year flow rate target. The foregoing considerations suggest that stormwater quantity control within valley locations would be required regardless of whether controls would be provided within new development areas, and further that, the additional storage required to offset peak flow increases due to future development can be most economically implemented at these sites.

Notwithstanding, new developments, in addition to water quality storage, may require some degree of on-site water quantity storage to address local flood and erosion impacts, and in some cases (primarily in the Upper Davis Creek Subwatershed) additional facilities are currently proposed as part of pending future development. These facilities have been included in the current hydrologic analysis.

Table 6.3 provides a summary of existing and proposed peak storm flow rates for the 100 year event at various locations along the Red Hill Creek Expressway

TABLE 6.3

RED HILL CREEK EXPRESSWAY (MUD STREET TO BRAMPTON STREET)
IMPACT PREDICTION AND MITIGATION
SURFACE WATER
DESIGN FLOW RATES (m^3/S)

Location	Future Land Use Conditions without Expressway or Expressway Stormwater Management[1]	Future Land Use with Expressway and associated Expressway Stormwater Management in place[2]
Outlet at Windermere Basin	174	106
Brampton St	171	101
CNR	171	100
Barton St.	173	97.9
Melvin St.	172	97.4
Queenston Rd.	166	90.5
D/S of King St.	165	93.8
Davis & Montgomery Creek	39.5	11.7
TH&B	122	76.8
Red Hill @ Greenhill Outlet	116	116
Albion Falls	57.1	57.1

1. Flows based on Future Land Use with Dartnall Road Flood Control Facility and "Approved" Stormwater Management Facilities In-Place
2. Flows as in 1. (above) with additional expressway stormwater management facilities (flood control) in place

Table 6.3 provides a summary of existing and proposed peak in-stream storm flow rates for the 100 year event at various two locations along the Q.E.W. section of the project.

As illustrated in the foregoing proposed, the stormwater quantity management would significantly reduce the in-stream peak flow rates and flood levels along the Red Hill Creek Expressway and Q.E.W. These reductions in flow rates are necessary to achieve the 100 year flood protection along the Red Hill Creek Expressway and Q.E.W.. Additional measures would also be required at the Q.E.W. to achieve 100 year event flood protection.

6.1.2.1 Culvert/Bridge Sizing for Flood Control

Mainline Crossings

The size of bridges and culverts which cross the Red Hill Creek affects a range of issues including:

- Upstream flood levels
- Stream flow velocity and channel erosion/stability
- Fish passage
- Recreational Access
- Wildlife movement

Hence, the sizing of bridge and culvert structures would be based on achieving size requirements for each of these issues. Ultimately each crossing structure size would be based on a composite of each of these issues. The hydraulic opening size required for mitigation of flood impacts has been based on hydraulic modelling results to achieve required flood protection of the Red Hill Creek Expressway and Q.E.W. Ultimately culvert sizes (to accommodate stable stream morphology, wildlife movement and recreational access) would typically be larger than that required for flood conveyance.

Minor Culvert Structures

Relatively small culvert structures are required at approximately 11 locations along the expressway with a total approximate length of 900 m. For economic reasons, a standard cross-sectional size and shape for these culverts is preferrred

In most cases the opening area required for hydraulic performance would be less than 2 m^2 (i.e. 1 m x 2 m) with the exception of three locations where the estimated opening area would be approximately 4 m^2 (i.e. 2 m x 2 m) required to allow flood flows to access remnant portions of the flood plain opposite the expressway. At locations where smaller opening areas (i.e. less than $2m^2$) are required for hydraulic control (i.e. at the proposed Greenhill and Davis Creek stormwater quantity control facilities), the upstream end would be restricted to the required end area. Since these structures are hydraulic control structures, the shape and orientation is not critical.

Some of the available standard manufactured culvert sections are as shown on Figure 10- Options 1, 2, 3, and 4 Each of the optional culvert types shown would provide the necessary opening for hydraulic purposes. Several other factors need to be considered with the final selection of culvert. These include constructability, maintenance, longevity and cost.

For all of the options, it would be proposed to provide a natural stream bed. Therefore, all of the culverts would have a minimum 0.6m natural substrate through embedding the culvert below the inlet/outlet elevation. For the prefabricated options (Options 1, 2 and 3), it would be difficult to place the stream bed after the installation of the complete culvert due to its limited size. As such, cross walls, 0.3 - 0.6m high, would need to be constructed, possibly unfilled, to allow sediment to settle naturally between the walls. This would also serve as a sediment trap during the initial stages following construction. Option 4 is proposed as cast-in-place. As such, the stream bed can be placed prior to placement of the top slab. Cross walls would still be considered for this option to provide some stability of the stream base.

For maintenance during the operation of these culverts, a minimum width of 1.5 m to 1.8 m and a height of 1.8 m would be desirable to allow access via a small loader or equivalent equipment. To this end, the minimum culvert size of 1.8 m x 1.8 m has been suggested. This would preclude the horizontal shapes from the options shown, except where limited vertical space is available due to the required expressway elevations. As previously noted, the upstream end would be restricted (where necessary) to meet the hydraulic requirements. Removable inlet/outlet grates could also be provided to provide some security to the culvert.

Based on the expected design life span of the expressway, it is proposed that only reinforced concrete structures be considered.

Based on the foregoing, Option 2 has been proposed as the recommended standard culvert configuration, with units installed with the larger dimension along the vertical plane, except where available vertical clearance precludes such installation, (in these cases the unit would be installed with the larger dimension along the horizontal plane however maintenance access would be restricted).

Appendix D provides a summary of proposed culvert size for the Red Hill Creek Expressway section of the project.

6.1.2.2 Refinements to Expressway Vertical and Horizontal Alignment

There are a number of areas where modification to the expressway vertical alignment (or profile) and horizontal alignment have been considered and recommended. The primary areas which have been modified to address surface water impacts include:

- Shift in Expressway horizontal alignment (7 m approx.) adjacent to the TH&B crossing to accommodate proposed Red Hill Creek Channel (ref. Stream morphology Technical Report) and to accommodate proposed recreational trail.

- Lowered vertical profile at Barton Street (up to 1 m reduction). This reduction in vertical profile reduces the width of the expressway embankment by 4-6 m.

- Increase vertical profile at CNR crossing. The proposed elevation has been increased by approximately 0.4 m to provide the maximum available elevation for flood protection.

6.1.2.3 Q.E.W. and Interchange Options - Impact Mitigation Opportunities

Currently, the Q.E.W. is flood susceptible between a 5 and 10 year return period (based on future land use flow rates). Implementation of expressway stormwater management [quantity storage - ref. Sites 4 (Greenhill) and 7 (Davis Creek)] would reduce storm flow rates, and hence improve the flood susceptibility of the Q.E.W. to approximately the 20 year return period. Further improvements in creek/flood plain conveyance would be required to provide flood protection for the Q.E.W. to the 100 year design standard (as is common for 400 series highways).

Burlington Street Interchange Options A and B

Options A and B have similar impacts on the hydraulics of the Red Hill Creek, and would have minimal impact on hydraulic performance, as they require no additional encroachment into the flood plain of the Red Hill Creek. Both options A and B would provide opportunities for excavation of 400 m+/- floodplain (overbank) section of Red Hill Creek. This would provide approximately 12 m^3/s additional capacity to the zero freeboard point at the Q.E.W. [i.e. 81 m^3/s existing to 93 m^3/s mitigated (improved)] (ref. Figure 11).

Burlington Street Interchange Option C and C-1

Option C would require additional lands which would encroach into the flood plain by an additional 20 m+/- reducing flow capacity to the point of zero freeboard by 3 m^3/s to 78 m^3/s (ref. Figure 11).

Implementation of Option C-1 would result in a minor decrease in the flood conveyance capacity of the Red Hill Creek. The reduction in flood conveyance capacity is approximately 1.5% to the point of "zero freeboard" at the Q.E.W. (i.e. point at which Q.E.W. travelled lanes begin to flood; edge of pavement). This reduction in flood conveyance results from increased hydraulic constriction of the Red Hill Creek flood plain caused by an additional bridge crossing and fill material encroaching into the flood plain for entry/exit ramps.

Although the hydraulic impacts of Option C-1 are minor, the primary consequence of this option is that, the addition of ramps along the south limit of the Q.E.W. would preclude opportunities to improve the flood conveyance of the Red Hill Creek, through flood plain excavation along the south limit of the Q.E.W. (i.e. north channel bank), as proposed under interchange Options A and B.

In order to improve flood protection under Option C-1, excavation of the flood plain along the south bank of the Red Hill Creek channel has been proposed for consideration.

The potential excavation would involve removal of fill material within a zone approximately 20 metres in width, along the south bank of the Red Hill Creek. The existing flood plain would be excavated to an elevation of approximately 74.8 m (i.e. long term lake level), thereby creating a shoreline marsh

A number of flood plain excavation sub-alternatives have been considered as outlined below (ref. Table 6.4):

- 20 m wide flood plain excavation from approximately the Woodward Avenue bridge structure to the low point in the Q.E.W. profile (i.e. Q.E.W. Station 20 to 50). The excavation would occur along the south limit of the Q.E.W. (i.e. north bank of Red Hill Creek) whenever possible and along the south bank of the Red Hill Creek, only where excavation along the north bank is infeasible. This basic flood plain excavation alternative would encroach on the Regional Water Filtration Plant property and would require construction of local revetment works and possible alteration to an internal access road. The feasibility of the encroachment has not been confirmed, therefore the assessment includes sub-alternatives:

    - with excavation at the Water Filtration Plant Site, and,
    - without excavation at the Water Filtration Plant Site,

- In addition to the basic flood plain excavation, additional excavation of an area which currently is used as a ball diamond in Globe Park has been assessed. This excavation would occur along the south bank/flood plain of Red Hill Creek, and would require removal of the ball diamond.

- The effect of additional excavation of the Red Hill Marsh has also been assessed This sub-alternative was identified through the Red Hill Creek Watershed Plan, as an measure to improve aquatic and wetland habitat. The effect of this option on hydraulics is minimal (ref. Table 6.4) due to the location of the excavation which is primarily upstream of the Q.E.W. low point.

Depending on the specific mitigation (excavation) option selected, the flood protection of the Q.E.W. would improve to approximately the 50 year event and improve flood conveyance by a approximately 12% - 21%.

Other alternatives for improvement in flood protection of the Q.E.W. (i.e. 100 year design event) may be attained through the following (which may be considered as stand-alone or supplemental alternatives):

(i). Increase the conveyance capacity of the cross culvert which connects the Red Hill Creek to Van Wagner's Marsh to the north. The required alteration would involve increasing the capacity of this culvert to convey flood flows only (i.e. no change to baseflow connection) from Red Hill Creek to Van Wagner's Marsh by temporarily 'storing' the excess flow in the marsh. There is a 20 m wide bridge structure beneath the Q.E.W. core lanes, hence depending on the structural condition of this bridge, alteration of the end (culvert) sections only may be required. This option may also require local re-grading of Van Wagner's Beach Road and local topography under a 'worst case' scenario.

(ii). Slightly increasing the ramp profile along the south limit of the Q.E.W. (maximum increase of 0.35m). Thereby preventing spill across Q.E.W. up to the 100 year design event. Notwithstanding this option may have a transferred impact upstream on the Red Hill Creek Expressway which would need to be assessed.

Table 6.4 summarizes performance of the various interchange options and mitigative works considered to date.

TABLE 6.4

SUMMARY OF HYDRAULIC PERFORMANCE OF BURLINGTON STREET INTERCHANGE OPTIONS

Option	Mitigation						Hydraulic Performance		
	20 m wide Floodplain Excavation (total)		Additional Excavation @ Ball Diamond	Additional Excavation @ Red Hill Marsh	Widening of Burlington Street Bridge (10 m)	Expressway Stormwater Management[1]	Flood Flow to on-set of flooding (m^3/s)	Change in Flow Capacity (%) from Existing Conditions (to "Zero Freeboard" condition)	Flood Protection Return Period (years) to "Zero Freeboard" Condition
	With floodplain excavation at Water Filtration Plant	Without floodplain excavation at Water Filtration Plant							
Existing Q.E.W.	N/A	N/A	N/A	N/A	N/A	Dartnall only	80.5	N/A	5
Existing Q.E.W.	N/A	N/A	N/A	N/A	N/A	Dartnall/ Greenhill/ Davis	80.5	N/A	20
Option A, B - with flood plain excavation	N/A	N/A	N/A	N/A	N/A		94.5	17	50
Option C-1 No Mitigation							79.5	-1.5	20
Option C-1 Mitigation Options	X						94	17	50
	X		X				97.5	21	50
	X		X	X			97.5	21	50
		X					90.3	12	20 (close to 50 year)
		X			X		93	15.5	50

1. All flows are based on approved future land use with "approved" stormwater management facilities in place
N/A - Not applicable
X - included in mitigation strategy

At this time, the recommended stormwater quantity management mitigation would include:

- Implementation of upstream stormwater quantity storage facilities at Greenhill and Davis Creeks

- Consideration for a 20 m wide excavation of Red Hill Creek flood plain to elevation 74.8 m; excavation would extend from the Woodward Avenue structure to the low point of the Q.E.W. 1050 m upstream.

- Over-sizing the Burlington Street bridge structure which is proposed for replacement; a 10 m over-sizing (beyond existing geometry) has been suggested [Note: Additional analysis is currently underway as part of further impact assessment refinement and preliminary design to further optimize the proposed over-sizing with respect to hydraulic performance, cost and construction issues].

- Raising the elevation of the East - South Red Hill Creek Expressway ramp by approximately 0.35 m as supplemental or stand-alone measure to improve flood the protection of the Q.E.W.

These recommendations are preliminary and would be refined through further preliminary and detailed design of stormwater management for this location.

6.2 Stormwater Quality

Stormwater quality management criteria, typically applied to highway projects, are based on managing the water quality impacts from new pavement or impervious areas, in accordance with Ministry of Environment and Ministry of Transportation Policies (ref. *Stormwater Management Practices - Planning and Design Manual, MOEE, 1994 and Ministry of Transportation Directive B-237, 1989*). Typically facilities are sized to provide water quality performance commensurate with the sensitivity and value of the aquatic habitat of the receiving watercourse (ref. Ministry of Natural Resources - Fish Habitat Protection Guidelines for Developing Areas, March 1994). The maximum pollutant removal efficiency of stormwater management practices ranges from 50-90% depending on the specific pollutant constituent and the specific practise.

Given the foregoing, any stormwater management practise will have some residual water quality impacts, even if it designed to provide protection to the highest Habitat Protection Level (i.e. Level 1).

Based on the current "stressed" condition of the Red Hill Creek, and objectives of initiatives such as the Hamilton Harbour Remedial Action Plan (RAP), and Red Hill Creek Watershed Plan, the stormwater quality mitigation criteria which has been established for the Red Hill Creek Expressway and Q.E.W. Interchange is more stringent than typically applied to highway/development projects. Specifically, the Federal Department of Environment and Provincial Agencies have indicated the Expressway project should result in no further degradation of in-stream water quality in accordance with MOEE Policy 2:

"Water Quality which presently does not meet the Provincial Water Quality Objectives shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the Objectives."

Based on the limitations in pollutant removal performance of stormwater management facilities (i.e. maximum removal 50-90%), mitigation for stormwater quality must focus on providing treatment to both existing developed lands, as well as new pavement areas, such that no increase and where possible a net reduction in pollutant loading, is achieved.

There are two primary methods of addressing stormwater quality impacts of the project:

- Management of stormwater runoff from the new roadway surfaces
- Supplemental stormwater quality measures/opportunities - to address existing pollutant sources

Management of Stormwater Runoff from the Expressway

Stormwater Management Practices (SWMP's) applicable to addressing expressway water quality impacts would primarily be structural techniques such as constructed wetland and wetpond facilities, grassed swales, and filter strips, although other non-structural measures such as modifications to maintenance programs would also be applicable. Each SWMP functions to reduce the amount of pollutants which reach the receiving watercourse.

Supplemental Stormwater Quality Measures/Opportunities

In order to entirely address/mitigate the stormwater quality impacts of the project, additional measures need to be considered. The range of supplemental opportunities/measures are described in the Red Hill Creek Watershed Plan and supporting technical reports [(ref. Opportunities for Management of Stormwater (Quality and Quantity) Streams and Groundwater, Philips Planning and Engineering Limited 1998)]. The primary supplemental opportunities which have been considered as part of the IADP to mitigate project impacts include:

- Combined Sewer Overflow (CSO) abatement - Red Hill Valley Facility
- Stormwater Retrofit Facilities (constructed wetlands and wetponds) at existing outfall locations adjacent to the proposed expressway, combined facilities which provide treatment to both new expressway paved areas and existing development

6.2.1 Mitigation Technique-Screening/Assumptions

Table 6.5 provides a summary of the primary stormwater management techniques considered for expressway stormwater mitigation.

TABLE 6.5

SUMMARY OF STORMWATER MANAGEMENT QUALITY TECHNIQUES FOCUSSED ON PROJECT IMPACT MITIGATION

Technique Description	Comment and Screening Results
Constructed Wetlands	• Provide excellent pollutant removal efficiency • Compatible with flat topography and surrounding terrestrial/aquatic habitat which is predominately wetland/marsh. • Compatible with storm sewer collection systems • Can be adapted to provide spill control function • Drainage areas greater than 5 ha are preferred, however high ground water/harbour levels would allow for smaller minimum drainage areas adjacent to the Q..E.W. • **Carried Forward for drainage areas greater than 3 hectares**
Grassed Swales with Buffer strips/filter strips	• Compatible with local flat topography • Use should be limited to drainage areas less than 2 ha. • Pollutant removal is good however typically less effective than constructed wetlands • Performance can be enhanced through use of buffer of filter strips at end of swale system • **Carried forward for drainage areas less than 2 ha**
Infiltration techniques (pervious pipes and catchbasins, infiltration basins,)	• Not feasible due to high ground water table (harbour and lake levels) • **Not Carried Forward**
Oil Grit Separators	Not feasible due to: ⇒ high maintenance requirements ⇒ limited pollutant removal performance ⇒ limited depth of cover and elevation to drainage outlets ⇒ high groundwater tables • **Not Carried Forward**
Wet ponds	Less compatible with surrounding topography and terrestrial/ aquatic habitat Provides good pollutant removal efficiency Compatible with storm sewer collection systems Can be adapted to provide spill control function Drainage areas greater than 5 ha are preferred • **Carried Forward where constructed wetlands cannot be accommodated due to spatial constraints and topography**

In order to maximize pollutant removal, all stormwater management practices proposed to treat expressway runoff have been sized to provide Level 1 Habitat Protection storage (i.e. most stringent criteria) in accordance with the current provincial guidelines (ref. Stormwater Management Practices - Planning and Design Manual , MOEE, 1994).

At retrofit locations, facilities have been sized to provide the maximum storage attainable in the context of spatial and topographic constraints up to Level 1 criteria where possible.

Stormwater quality impacts for each section of the project have been assessed on the basis of the proposed increases in impervious area due to new ramps, lanes and shoulders. The assessment has been based on a mass balance (spreadsheet) approach which calculates annual loading of various pollutants based on land use. The primary impact associated with the each of the interchange options is an increase in the various pollutant constituents, particularly metals and PAH.

Control of stormwater quality only effects stream flow rates under moderate events and would have virtually no effect on in-stream flow rates under severe storm events. Since the objective is extended detention of stormwater runoff (i.e. 24-48 hours) to facilitate pollutant removal, these facilities would serve to minimally reduce peak flow rates and augment low flow over the 1 - 2 days following a runoff event. These benefits to the overall watershed hydrologic response have conservatively not been included in hydrologic modelling of mitigation performance.

6.2.2 Proposed Stormwater Quality Impact Mitigation

As noted in the Screening Results, constructed wetlands, wet ponds, grassed swales and buffer/filter strips have been screened as the most appropriate stormwater management practices for this section of the project.

The location of stormwater management facilities (i.e. wetlands and wet ponds) has been based on the following factors:

- Size of expressway or interchange drainage area that can be conveyed to each location. A minimum drainage area of 3 - 5 hectares is typically required to sustain a stormwater wetland.

- Expressway grading; wherever possible, facilities have been proposed within interchange loops and along the inner side (low side) of super-elevated sections.

- Remnant channel locations (i.e. where re-alignment of the creek channel is required the remnant have been considered for stormwater management). Use of these locations for stormwater management has benefits relating to minimizing requirements for grading, maintaining soil moisture conditions along the remnant channel banks, and opportunities to treat runoff from existing development where existing stormwater outfalls drain to these channel sections.

- Preservation of natural habitat; wherever possible facilities would be located to minimize impact on valued aquatic and terrestrial habitats.

- Location with respect to the Red Hill Creek Channel and Floodplain; wherever possible proposed stormwater management facilities have been proposed to be located outside of the Red Hill Creek channel and flood plain (i.e. on the opposite side of the expressway embankment). These locations would be less susceptible to stream induced flooding and hence would be less susceptible to re-suspension of pollutants during storm events.

Red Hill Creek Expressway (Mud Street to Highway 20)

As outlined Section 5.2, unmitigated impact of stormwater runoff from the entire expressway project would increase annual pollutant loads from 0.04% to 11.6% depending on the pollutant. The Red Hill Valley section of the project contains the majority of the new pavement areas. Unmitigated, stormwater runoff from this section would increase pollutant loading by 0.05% to 10.5%.

Measures proposed to mitigate these impacts include:

- Stormwater management facilities (constructed wetlands and wetponds)
- Grassed swales and filter strips
- Retrofit stormwater management facilities (constructed wetlands and wetponds) at existng outfall and combined stormwater management facilities which provide stormwater quality treatment to (expressway runoff as well as existing development)
- CSO abatement - Valley Pipe Storage Facility located primarily within the expressway corridor

An integrated plan of applying these various techniques into the expressway project, would reduce pollutant loads over existing conditions from a maximum of 5.7% for Total Suspended Sediment (TSS) to a minimium reduction of 0.13 % for Biological Oxygen Demand (BOD_5). Appendix E provides a summary outline of unmitigated stormwater quality impacts, as well as the effectiveness of the proposed mitigation.

Drawing/Figures 1 and 9 illustrates the proposed location of stormwater management facilities for the Red Hill Creek Expressway section of the project; Table 6.6 summarizes the drainage area storage volume associated with each facility.

TABLE 6.6

RED HILL CREEK EXPRESSWAY
IMPACT PREDICTION AND MITIGATION
MUD STREET TO BRAMPTON STREET
STORMWATER QUALITY AND LOCAL EROSION/FLOOD CONTROL FACILITIES

Facility Location Reference	Drainage Area (ha)		Approximate Water Quality Volume [1] (m^3)		Approximate Base Footprint (m^2) [1]		Type	Notes
	Expressway	External	Expressway	Expressway and External	Expressway	Expressway and External		
A-1	4.3	To Be Determined (maximum 90 ha)	1073	(2500-5000 available)	1500	5000 available	Due to spatial constraints a wet pond facility would be preferred	Opportunity to provide centralized stormwater management for future development
A	3.53	6.5+/-	495	800	1175	1 335	Due to spatial constraints a wet pond may be preferred	Additional storage volume to provide local erosion/flood control could be incorporated within footprint
B	3.53	2.5	495	555	1175	1 035	Quality - New	
C	4.32	3.88	605	860	1435	1 175		
D	1.88	-	265	-	625	-		
E	1.4	-	195	-	465	-		
F	1.9	5.3	265	575	635	960		
G	1.6	5.85	225	600	535	1 000		
H	--	To be determined (1. 37m Dia. Sewer)	-	840 available	-	2 800	Quality - Existing	Addresses water quality from existing development (retrofit)
I	6.25	3.0	875	990	2085	2 065	Quality - New	Additional storage volume to provide local erosion/flood control could be incorporated within foot print
J	--	To be determined (1 73m Dia Sewer)	-	1200 available	-	4 000	Quality - Existing	Addresses water quality from existing development(retrofit)
K	2.9	--	405	-	966	-	Quality - New Tertiary - Combined	Potential location for CSO overflow (avoid residential area)
L	--	4.5	-	363	-	610	Quality - Existing	Addresses water quality from existing development (retrofit)

Stormwater Quantity - Flood Control Facilities

Facility Location Reference	Drainage Area (ha)	Storage Volume (m^3)	Type	Notes
Site 4 Greenhill	3950	300 000	Flood Control	Temporary (4-8 hours) Flooding of area upstream of control structure would occur for flows greater than bankfull discharge (10-12 m^3/s) Maximum Water level under 100 year flood approximately 99.0 m
Site 7-A Mount Albion Crossing	1500	297 000	Flood Control	Temporary (6-18 hours) Flooding of area upstream of control structure would occur for flows greater than 2.0 m^3/s. Maximum Water level under 100 year flood approximately 96.6 m

[1] Assuming Level 1 Habitat Protection and Constructed Wetland BMP

Location of constructed wetlands and swales/filter strips is flexible and may be altered, based on opportunities to integrate such facilities with existing terrestrial resources.

The surface area of constructed wetlands and swales/filter strips may vary by as much as 50% based on:

a) opportunities to integrate such facilities with existing terrestrial resources
b) refinement of drainage areas as part of detailed design,
c) specific site landscaping considerations, and,
d) specific site features and constraints such as topography, soil, and sub-soil characteristics

Empirical pollutant removal efficiencies assumed for each stormwater management practice used in the assessment are as outlined in Table 6.7:

TABLE 6.7

SUMMARY OF ANNUAL POLLUTANT REMOVAL EFFICIENCIES (%)

PARAMETER	Wetland Designed for Level 1 Habitat Protection	Wetpond/Wetland Designed for Level 2 Habitat Protection	Grassed Swale Riparian Buffers
TSS	80	70	50
BOD_5	45	30	60
Copper	65	57	60
Zinc	55	33	60
Faecal Coliform	80	33	80
PAH	70	52	70
Total Phosphorus	55	32	60

NOTE: Pollutant removal efficiency for retrofit facilities varies at each location based on: Drainage Area, Type of Land Use and available Storage Volume

Q.E.W. (Highway 20 to Burlington Street)

Various stormwater quality management options have been evaluated for the Q.E.W. area on the basis of providing Level 1 Habitat Protection to the whole area as opposed to simply providing treatment for new pavement only.

As outlined in Section 5.2, the Burlington Street - Q.E.W. Interchange Options A and B, in conjunction with the Red Hill Creek Expressway - Q.E.W. Interchange would increase pavement area within the study area by 7.2 and 7.0 ha respectively. Without mitigation, annual pollutant loading on a watershed basis would, ranging from a maximum increase of 2% in annual Copper loading to essentially no change in faecal coliform contributions.

With the proposed mitigation (i.e. combination of constructed wetlands, grassed swales and buffer strips, ref. Figures 2 and 3), pollutant loads would decrease over existing conditions by a maximum of 1.8%.

Appendix E provides a summary of both mitigated and unmitigated impacts.

Interchange Options C and C-1, in conjunction with the Red Hill Creek Expressway - Q.E.W. interchange would result in slightly larger increases in stormwater pollutant loading to the Red Hill Creek than Options A and B, due to the introduction of additional paved surfaces for ramps and additional lanes (i.e. 10 ha new pavement - total). The maximum increase in individual pollutant loading has been assessed as a 2.8 % annual increase for copper. Other parameters such as total suspended solids, BOD_5, zinc, phosphorous and PAH would also increase between 0.7% - 1.5%.

In order to mitigate these impacts, stormwater management techniques such as, constructed wetlands, grassed swales and filter/buffer strips have been proposed to be implemented throughout the Burlington Street and Red Hill Creek Expressway - Q.E.W. Interchanges (ref. Figures 4 and 5). The implementation of stormwater management facilities has been suggested to capture and treat stormwater runoff from both existing and proposed paved surfaces of the Q.E.W. and new interchange areas. This approach would result in net reductions in pollutant loading to the Red Hill Creek ranging from 0.3% to 1.4%.

[Note: The predicted reduction in pollutant loading does not account for "passive" pollutant removal which currently occurs in existing roadside swales adjacent to the Q.E.W.]

At this time the recommended Stormwater Quality Management Mitigation for Option C-1 (preferred) includes:

- Provision for stormwater quality treatment for the existing Q.E.W. and interchange areas, as well as all additional pavement areas associated with the two new interchanges.

- Constructed stormwater wetlands designed to Level 1 Habitat protection sizing criteria, for drainage areas greater than 3.0 hectares.

- Grassed swales with buffer/filter strips for minor drainage areas. Wherever possible these swales and filter strips would be located away from the Red Hill Creek channel and flood plain to minimize potential for resuspension of pollutants.

- A storm sewer collection system has been proposed (rather than roadside swales) along the Q.E.W. corelanes and ramps to minimize physical roadway encroachment into the wetland areas where the roadway is within the Red Hill Marsh and Van Wagner's Marsh.

Further optimization of facility sizing and location is currently on-going based on additional grading and design information.

6.2.3 Operation and Maintenance of Proposed Mitigation (Stormwater Management Practices)

Stormwater management facilities will require periodic maintenance to sustain long term effectiveness for pollutant removal. The type of required maintenance activity would vary for each of the different stormwater management practices. Table 6.8 outlines the type and frequency of each required maintenance activity for the various stormwater management practices considered for the Project.

TABLE 6.8

SUMMARY OF MAINTENANCE ACTIVITIES FOR VARIOUS STORMWATER MANAGEMENT PRACTICES PROPOSED FOR THE RED HILL CREEK EXPRESSWAY

Stormwater Management Practice	Maintenance Activity	Frequency of Activity (years)	Cost Ranking of Activity
Constructed Wetland	Inspection	1	LOW
	Debris Removal	1	LOW
	Vegetation Replanting/Maintenance	5-10	MEDIUM
	Grass cutting/weed control	1	LOW
	Outlet adjustment	as required	LOW
	Sediment removal from forebay	5-10	MEDIUM
	Sediment removal from wetland area with replanting	25-35	HIGH
	Overall Cost Ranking		***MEDIUM-HIGH***
Wet Ponds	Inspection	1	LOW
	Debris Removal	1	LOW
	Vegetation Replanting/Maintenance	5-10	LOW- MEDIUM
	Grass cutting/weed control	1	LOW
	Outlet adjustment	as required	LOW
	Sediment removal from forebay	5-10	MEDIUM
	Sediment removal from wetpond area with replanting	25-35	HIGH
	Overall Cost Ranking		***MEDIUM-HIGH***
Grassed Swales	Inspection	1	LOW
	Debris Removal	1	LOW
	Grass cutting/weed control	1	LOW
	Sediment removal/grading with reseeding/planting	7-10	MEDIUM
	Overall Cost Ranking		***LOW***
Buffer Strips/Filter Strips	Inspection	1	LOW
	Debris Removal	1	LOW
	Sediment removal/grading with reseeding/planting	10-12 (if required)	MEDIUM
	Overall Cost Ranking		***LOW***

6.2.4 Construction Impact Mitigation

Environmental Management/Site Supervision

Environmental management during the construction phase of the project will play a vital role in ensuring environmental protection objectives are realized including minimizing stormwater quality impacts. A detailed Environmental Management Plan will be developed as part of final design, however it is anticipated that the Environmental Management Plan will include:

- consideration for an Independent Environmental Site Manager (ESM) to co-ordinate site activities and ensure compliance
- establishment of a multi-disciplinary management team, headed by ESM, with expertise in the disciplines of engineering, environmental monitoring, terrestrial, and fisheries resources to provide timely input to construction issues as they arise
- a rigorous reporting protocol with a built-in contingency plan for violations

- reinforcement of environmental constraints with successful contract bidder and utility companies through a pre-construction meeting to review environmental constraints, staging and construction practices
- monitoring of construction practices, and environmental indicators (i.e. water quality parameters) by a qualified environmental inspector (not to be confused with the ESM mentioned earlier)
- regular meetings with various contractors, inspectors, and agency staff to co-ordinate construction staging and construction practices will be incorporated as necessary. Regulatory and enforcement agencies will be kept informed of construction works in general.

Erosion and Sediment Control Plan

As outlined in Section 6.2.4, the impacts of construction activities on stormwater quality, if proper mitigation is not applied, can be significant and such impacts are primarily related to increased sediment loading to the receiving watercourse. Although the potential for increased sediment loads during construction cannot be entirely mitigated, measures can be implemented to minimize stormwater quality impacts.

The primary means of mitigating stormwater quality impacts of construction is through implementation of an Erosion and Sediment Control Plan. The Hamilton and Halton Region Conservation Authorities have prepared guidelines for preparation of Erosion and Sediment Control Plans including detailed specification of erosion and sediment control practices (ref. *Keeping Soil on Construction Sites*, HRCA, 1994). A detailed Erosion and Sediment Control Plan will be completed as part of the detailed expressway design and will be based on the these guidelines .

The most effective Erosion and Sediment Control Plans focus on controlling erosion (i.e. preventing erosion of the soil) rather than sediment control (capturing eroded sediment before it construction site). Table 6.9 illustrates the relative effectiveness of Erosion and Sediment controls as compared to unmitigated construction impacts.

TABLE 6.9

SUMMARY OF SEDIMENT AND EROSION CONTROL MEASURE PERFORMANCE BASED ON STORM MEDIAN TOTAL SUSPENDED SEDIMENT CONCENTRATIONS (MG/L)

Undisturbed Pre-construction	No Erosion or Sediment Control	Erosion Control only	Erosion and Sediment Controls	Post construction
25	4145	680	283	50

[1] Source: Schueler and Lugbill, 1990 - Piedomont Construction Sites, as cited in Metropolitan Washington Council of Goverments *Clearing and Grading Strategies for Urban Watersheds*, 1995

The Erosion and Sediment Control Plan for Construction of the expressway; would include:

Erosion Control Measures (most effective means of reducing sediment deposition and erosion)

- Restricted clearing and grading (minimize disturbance for access)

- Phased Construction which limits the amount of area disturbed for clearing and grading
- Timely vegetative/stabilization of areas disturbed during construction (including use of erosion control blankets, seeding, etc..)
- Topsoil Preservation (stockpiling, stabilization)

Sediment Control Measures (secondary effectiveness)

- Install and maintain sediment control devices during construction (sediment basins, silt fencing, rock check dams, vegetated filters)

Other elements of the plan would include:

- Monitoring/Supervision of Sediment and Erosion Control Plan through the Environmental Management
- Maintenance of Sediment Control Devices
- Designate fueling areas away from watercourses and incorporate spill containment at fueling areas
- Maintain in-stream spill containment equipment on-site

6.3 Further Design Refinements

The mitigation measures documented in this report will be refined through the public and stakeholder consultation process as well as through the detailed design process. As noted throughout this report the predicted impacts and mitigation performance are expected to vary slightly due these refinements. In most cases the variation is expected to be approximately 5-10%.

For these reasons the methods for prediction of impacts and mitigation have incorporated conservative elements wherever possible. In addition, post construction monitoring of performance will also be undertaken to ensure that performance objectives are met. Where monitoring indicates that performance objectives are not being met or improvements in performance can be realized through design modifications, such modifications will be undertaken as part of the Environmental Management Plan.

The primary refinements to the proposed mitigation measures for each section of the expressway are expected to include the following:

Red Hill Creek Expressway(Mud St. to Brampton Street)

- Incorporation of Public and Stakeholder feedback received from IADP Process into stormwater management design.

- Refinement of water quality facility design, sizing and location with respect to local terrestrial and aquatic habitat, operation and maintenance, and construction considerations. It is expected that individual facility sizes may vary by up to 50%, however on balance the overall area required for stormwater management facilities will not vary significantly

- Refinement of stormwater quantity facility design and performance with respect to compatibility with stream morphology objectives and operation, maintenance, and construction considerations.

- Refinement of bridge crossing sizes and location in conjunction with the detailed stream design, fisheries, terrestrial and recreational access, and mitigation design.

- Provide input to expressway design aspects, which relate to stormwater and stream flow such as:

    - determining appropriate stormwater collection systems required for each area of the expressway and to stormwater management facility

    - detailed design of erosion protection measures where required for protection of the expressway:
        - Where in-stream measures would be designed in conjunction with the proposed natural channel design principles (ref. Stream morphology/stability mitigation report) and would focus on using natural materials wherever possible (i.e. root wads, plantings, cribwalls).
        - Out-of-stream erosion protection for major storm events would also be included to reduce potential for damage to the expressway under Regional storm events

Q.E.W. (Highway 20 to Burlington Street)

- Incorporation of Public and Stakeholder feedback received from IADP Process into stormwater management design.

- Refinement of water quality facility design, sizing and location with respect to local terrestrial and aquatic habitat, operation and maintenance, and construction considerations.

- Refinement of hydraulic mitigation (i.e. floodplain excavation options, bridge replacement widenings, and ramp elevation) in relation to adjacent terrestrial and aquatic habitats, as well as construction and cost considerations.

- Provide input to interchange design aspects, which relate to stormwater performance such as:

    - determining appropriate stormwater collection systems required for each stormwater management facility,
    - evaluation of impacts of centreline barrier wall which are typically included in 400 series highways. Determination of preferred barrier configuration and opening requirements will be undertaken in conjunction with assessment of such impacts on upstream sections of the Red Hill Creek Expressway.

7. REFERENCES

Aquafor Beech Ltd., "Class EA: Red Hill Creek CSO control, ESR Draft Report." Prepared for the Regional Municipality of Hamilton-Wentworth. 1997

Barrett, M, Zuber R.D., Malina J. F. Charbeneau R.J., Ward G.H. and, Collins E.R, Centre for Research in Water Resources, University of Texas., "A Review and Evaluation of Literature Pertaining to the Quantity and control of Pollution from Highway Runoff and Construction", April 1993

Dougan & Associates "Terrestrial Resources - Phase 1 Background Inventory - Draft Technical Report - Red Hill Creek Watershed Plan" , July 1997, (in progress),

Hamilton Region Conservation Authority and Halton Region Conservation Authority "Keeping Soil on Construction Sites", Erosion & Sediment Control Guidelines for Hamilton Harbour Watershed and Region of Hamilton-Wentworth, April 1994

Liang, W.Y. and M.K. Thompson, "Performance Assessment of an Off Line Stormwater Management Pond: Heritage Estates Stormwater Management Pond, Richmond Hill, Ontario". Prepared for MOEE and Metro Toronto & Region Conservation Authority., 1996

Malina J. F. Charbeneau R.J., Ward G.H. and Barrett, M, Zuber R.D. Collins E.R. "A Review and Evaluation of Literature Pertaining to the Quantity and control of Pollution from Highway Runoff and Construction", April 1993, Centre for Research in Water Resources, University of Texas

Maltby L., Forrow D.M., Boxall, A.B.A, Calow P., and C. Betton, "The Effect of Motorway Runoff on Freshwater Ecosystems 1. Field Study" and "2. Identifying Major Toxicants", 1995, University of Sheffield

Mar, B. W. et al., " Washington State Highway Runoff Water Quality Study 1977-1982", WA-RD-39.16, Washington State Department of Transportation, Olympia, WA., 1982

Marsalek J, Brownlee B., Mayer T. Lawal S., and G. Larkin "Heavy Metals in highway bridge runoff , 1997, National Water Research Institute , Environment Canada

Ministry of Environment and Energy (MOEE), "Water Management Policies, Guidelines, Provincial Water Quality Objectives", 1994

Ministry of Environment and Energy (MOEE), "Constructed Wetlands for Stormwater",1992

Paragon Engineering Effect of Proposed North-South Expressway on Peak Flows and Levels in Lower Red Hill Creek, November 1983

Philips Planning and Engineering Ltd. " Opportunities for Management of Stormwater (Quantity and Quality), Streams and Groundwater - Red Hill Creek Watershed Plan", January 1998

Philips Planning and Engineering Ltd. " Water Quality Report - Red Hill Creek Watershed Plan", August 1997

Philips Planning and Engineering Ltd. "Surface Water Report - Red Hill Creek Watershed Plan ", November 1997

Philips Planning and Engineering Ltd. "Montgomery Creek, Class Environmental Assessment, Stormwater Management ", August 1997

Philips Planning and Engineering, " Hydraulic Analysis and Detailed Design of TH&B to north of Queenston Road", November 1989

Philips Planning and Engineering, "Drainage Stabilization and Assessment Study Implementation Plan, Red Hill Creek ", November 1992

Philips Planning and Engineering, "Drainage Stabilization Re: Grades Separations at TH&B, King St. and Queenston Road, Red Hill Creek ", November 1991

Philips Planning and Engineering, "Hydraulic Analysis of Proposed Red Hill Creek Expressway, Red Hill Creek ", May 1990

Philips Planning and Engineering, "King Street Interchange - Detailed Hydraulic Analysis", August 1989

Philips Planning and Engineering, "Supplemental Analysis of Q.E.W.- Red Hill Creek Interchange - Spill Mitigation Evaluation", November 1996

Philips Planning and Engineering, "Mountain East-West and North-South Transportation Corridor - Drainage Study - Final Report" - July 1989,

Regional Municipality of Hamilton-Wentworth, Ministry of Transportation "Executive Summary, Red Hill Creek Expressway North-South Section", June 1998

Regional Municipality of Hamilton-Wentworth, "First Generation Plan- Red Hill Creek Watershed Action Plan- Final Draft", April 1998

Regional Municipality of Hamilton-Wentworth, Ministry of Transportation "Impact Assessment and Design Process, Red Hill Creek Expressway North-South Section- Draft Summary Report Volume 1", November 1997

Regional Municipality of Hamilton-Wentworth, "State of the Watershed Report, Red Hill Creek Watershed Planning", October1997

Regional Municipality of Hamilton-Wentworth "Proposed Assessment Process, Red Hill Creek Expressway North-South Section", February 1996

Regional Municipality of Hamilton-Wentworth "Exemption Order, Red Hill Creek Expressway North-South Section", May 1996

Regional Municipality of Hamilton-Wentworth "Mountain East-West and North-South Transportation Corridor - Supplementary Documentation- Environmental Assessment Submission", November, 1983

Schueler, T.R. and Lugbill, J. " Performance of Current Sediment Control Measures at Maryland Construction Sites", Metropolitan Washington Council of Governments, 1990

Schueler, T.R. Kimble, P.A., Heraty " A Current Assessment of Urban Best Management Practices - Techniques for reducing Non-point Pollution in the Coastal Zone", March 1992 Metropolitan Washington Council of Governments

Schueler, Thomas, " Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetlands in the Mid-Atlantic Region". Anacostia Restoration Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, 1992

Schueler, Thomas.R, "Controlling Urban Runoff: A practical Manual for Planning and Designing Urban BMPs". Prepared for Washington Metropolitan Water Resources Planning Board., 1987

Stoz, G., "Investigations of the Properties of Surface Water Runoff from Federal Highwaysin the FRG", The Science of the Total Environment, Vol. 59, : 329-337, 1987

United States Environmental Protection Agency, "Clearing and Grading Strategies for Urban Wetlands". Office of Wetlands, Oceans and Watersheds, Washington, DC., 1995

United States Environmental Protection Agency, " Natural Wetlands and Urban Stormwater: Potential Impacts and Management". Office of Wetlands, Oceans and Watersheds, Washington, DC., 1993

Vice, R.B., H.P. Guy, and G.E. Ferguson, "Sediment Movement in an Area of Suburban Highway Construction, Scott Run Basin, Fairfax County, Virginia", 1961-64. U.S.G.S. Water Suppl. Pap. 1591-E, 1969

Wanielista, M.P. and Y.A. Yousef, ,"Stormwater Management". John Wiley and Sons Inc, New York., 1993

Wenghofer, C, Duncan B., and J.Struger, August, 1997, "Red Hill Creek, Hamilton, Ontario - Water and Sediment Quality and Affects of Fish and Fish Habitat", prepared for Hamilton Region Conservation Authority as part of the Red Hill Valley Environment Rehabilitation Project

WRIS (Water Regime Investigations and Simulations Ltd.), A Fluvial Geomorphologic Inventory of Red Hill Creek and its tributaries, Waterloo, Ontario, Canada., 1997

Wolman, M.G., "Erosion in the Urban Environment", Hydrol. Sci. Bull. 20(1): 117-125, 1975

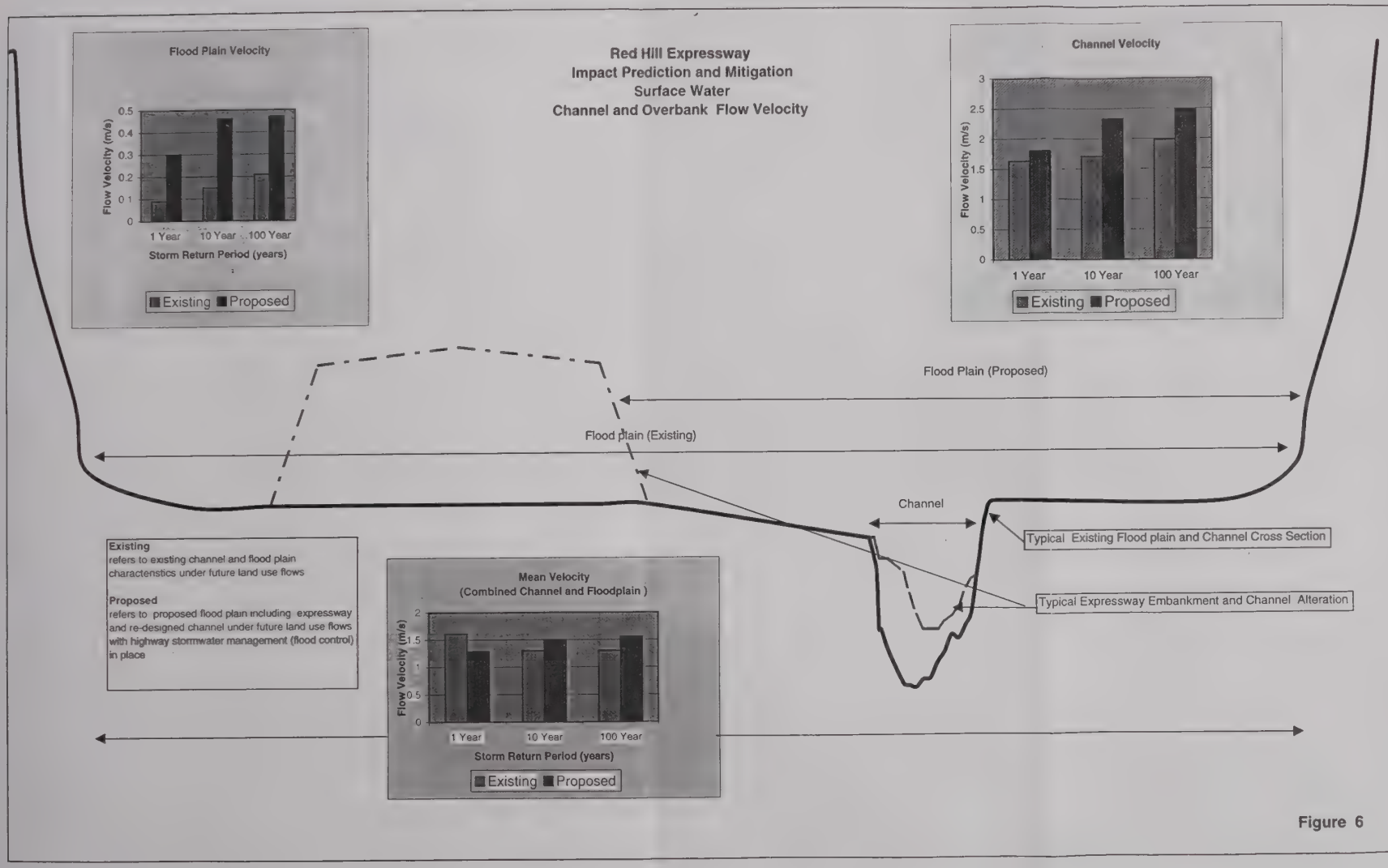

Red Hill Expressway
Impact Prediction and Mitigation
Surface Water
Channel and Overbank Flow Velocity
Flood Plain Velocity
Flow Velocity (m/s)
0.5
0.4
0.3
0.2
0.1
0
1 Year
10 Year
100 Year
Storm Return Period (years)
Existing
Proposed
Channel Velocity
Flow Velocity (m/s)
3
2.5
2
1.5
1
0.5
0
1 Year
10 Year
100 Year
Existing
Proposed
Flood Plain (Proposed)
Flood plain (Existing)
Channel
Typical Existing Flood plain and Channel Cross Section
Typical Expressway Embankment and Channel Alteration
Existing
refers to existing channel and flood plain charactenstics under future land use flows
Proposed
refers to proposed flood plain including expressway and re-designed channel under future land use flows with highway stormwater management (flood control) in place
Mean Velocity
(Combined Channel and Floodplain)
Flow Velocity (m/s)
2
1.5
1
0.5
0
1 Year
10 Year
100 Year
Storm Return Period (years)
Existing
Proposed

Figure 6

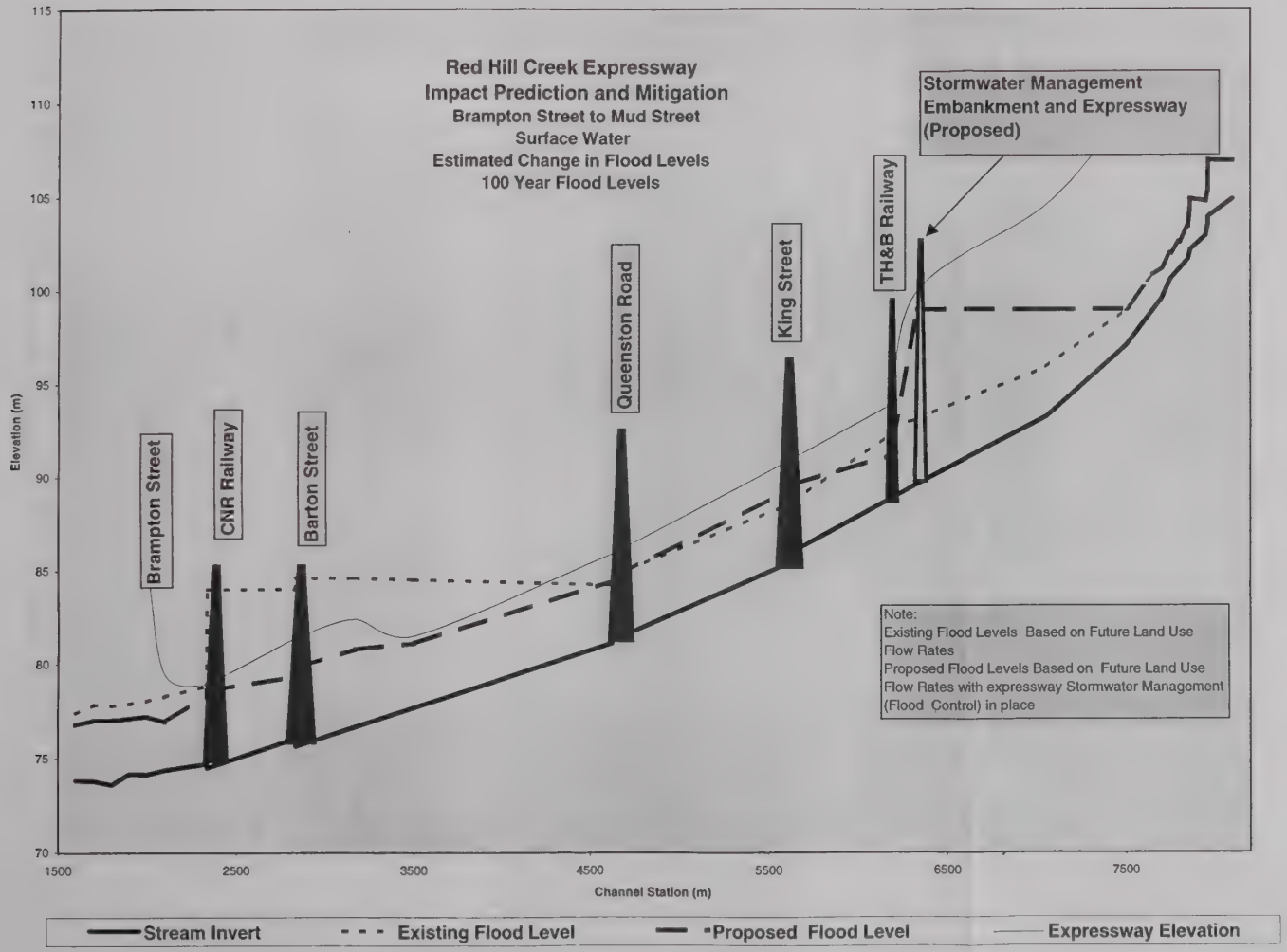

Red Hill Creek Expressway
Impact Prediction and Mitigation
Brampton Street to Mud Street
Surface Water
Estimated Change in Flood Levels
100 Year Flood Levels
Stormwater Management Embankment and Expressway (Proposed)
Brampton Street
CNR Railway
Barton Street
Queenston Road
King Street
TH&B Railway
Note:
Existing Flood Levels Based on Future Land Use Flow Rates
Proposed Flood Levels Based on Future Land Use Flow Rates with expressway Stormwater Management (Flood Control) in place
Elevation (m)
115
110
105
100
95
90
85
80
75
70
1500
2500
3500
4500
5500
6500
7500
Channel Station (m)
Stream Invert
Existing Flood Level
Proposed Flood Level
Expressway Elevation

Figure 7

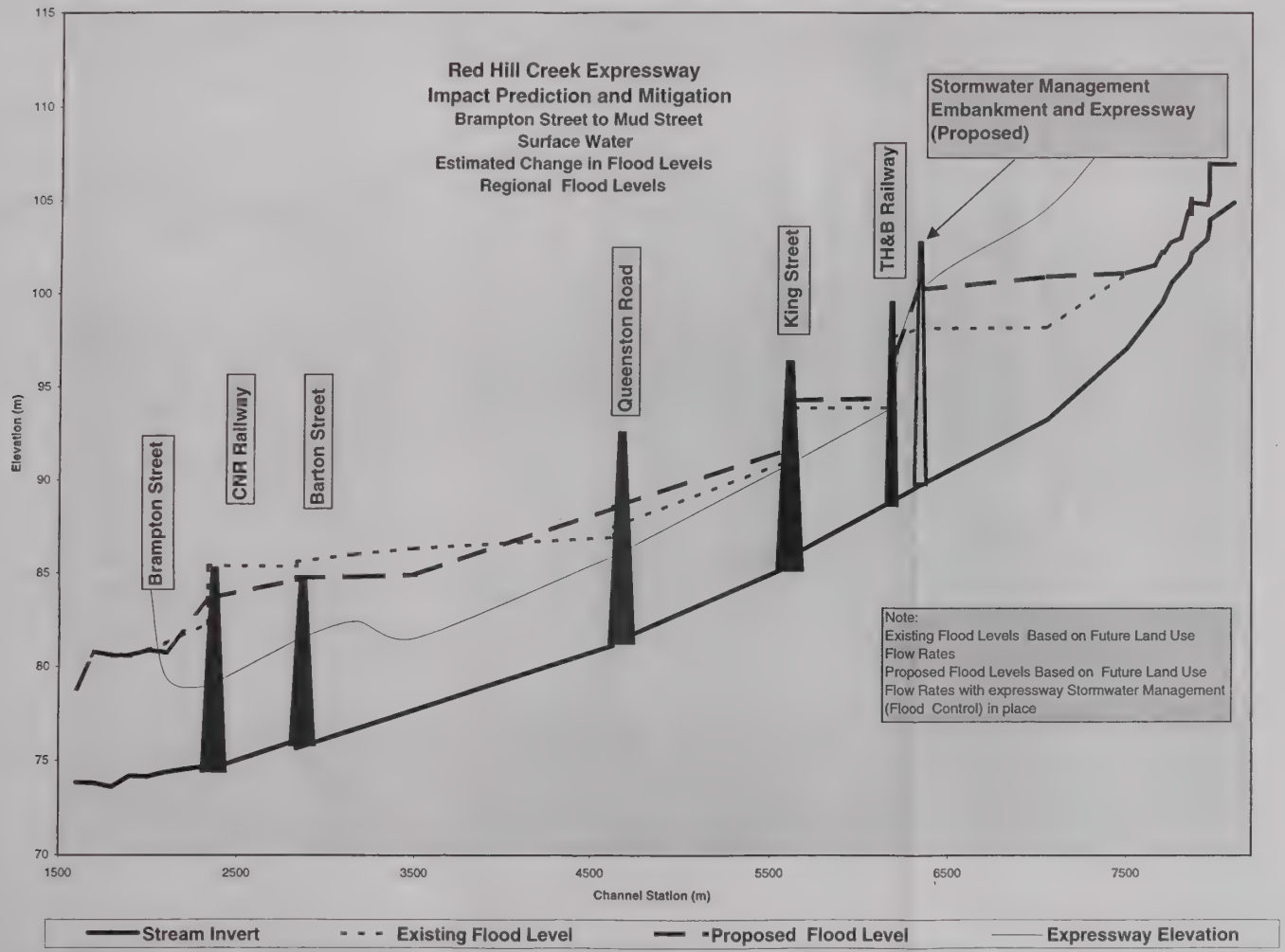
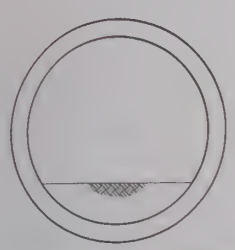

Red Hill Creek Expressway
Impact Prediction and Mitigation
Brampton Street to Mud Street
Surface Water
Estimated Change in Flood Levels
Regional Flood Levels
Stormwater Management Embankment and Expressway (Proposed)
Brampton Street
CNR Railway
Barton Street
Queenston Road
King Street
TH&B Railway
Note:
Existing Flood Levels Based on Future Land Use Flow Rates
Proposed Flood Levels Based on Future Land Use Flow Rates with expressway Stormwater Management (Flood Control) in place
Elevation (m)
115
110
105
100
95
90
85
80
75
70
1500
2500
3500
4500
5500
6500
7500
Channel Station (m)
Stream Invert
Existing Flood Level
Proposed Flood Level
Expressway Elevation

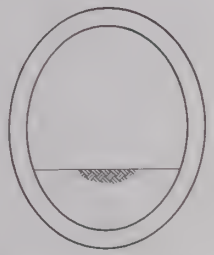
Figure 8

NOT TO BE USED FOR CONSTRUCTION | CONT No | WP No | SHEET 1

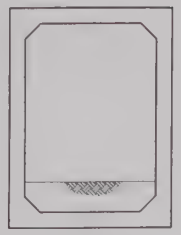


OPTION 1

2400ø PRECAST CONCRETE PIPE

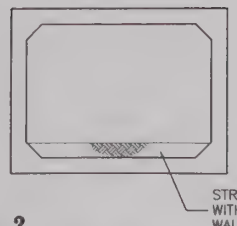


ELLIPTICAL PRECAST CONCRETE PIPE

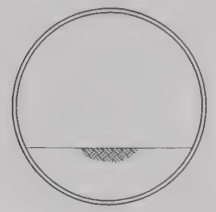


OPTION 2

2400x1800 PRECAST CONCRETE BOX

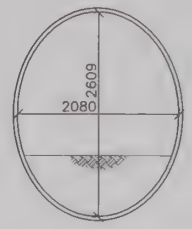


1800x2400 PRECAST CONCRETE BOX



OPTION 3

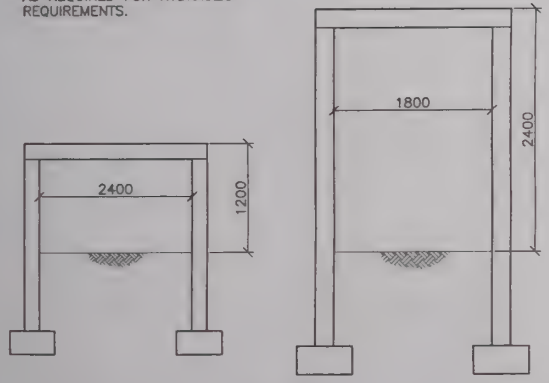
2400ø CORRUGATED STEEL PIPE



ELLIPTICAL CORRUGATED STEEL PIPE

NOTE:

END AREA TO BE RESTRICTED AS REQUIRED FOR HYDRAULIC REQUIREMENTS.



OPTION 4

1200x2400 OPEN FOOTING CULVERT

2400x1800 OPEN FOOTING CULVERT

ELEVATIONS

LOCATION	CREEK INVERT	TOP OF ROAD ℄ N.B.L.	TOP OF ROAD ℄ S.B.L.	LENGTH
MAINLINE CROSSING STATION 24+395	109±	114.5±	116±	94m±
MAINLINE CROSSING STATION 25+050	95±	100±	100±	78m±
MAINLINE CROSSING STATION 25+350	90.5±	95.5±	94.5±	65m±
KING E-W/N RAMP STATION 10+195	87.5±	93.5±	N/A	45m±
MAINLINE CROSSING STATION 26+160	86.4±	89.5±	90.5±	105m±
MAINLINE CROSSING STATION 26+700	82.3±	86.5±	86±	140m±
MAINLINE CROSSING STATION 27+120	81.3±	84±	84±	115m±
MAINLINE CROSSING STATION 27+480	80.3±	82±	82±	63m±
MAINLINE CROSSING STATION 27+760	79.0±	82±	82±	66m±
MAINLINE CROSSING STATION 27+920	78.3±	82.5±	82.5±	2x 50m±
MAINLINE CROSSING STATION 28+020	78.3±	82±	82±	70m±
			TOTAL LENGTH	940m±

COST EVALUATION

OPTION	COST $/m
OPTION 1 –	$1600
OPTION 2 –	$1800
OPTION 3 –	$1000
OPTION 4 –	$2000

NO	REVISIONS	DATE	INITIAL

Philips Planning Engineering Limited

DESIGNED BY: H.A.P.H. | CHECKED BY: | DRAWN BY: M.B.M. | CHECKED BY:

APPROVED — PROJECT DIRECTOR

APPROVED — MANAGER OF ENGINEERING

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

SPECIAL PROJECTS OFFICE

DATE: MAY 1998

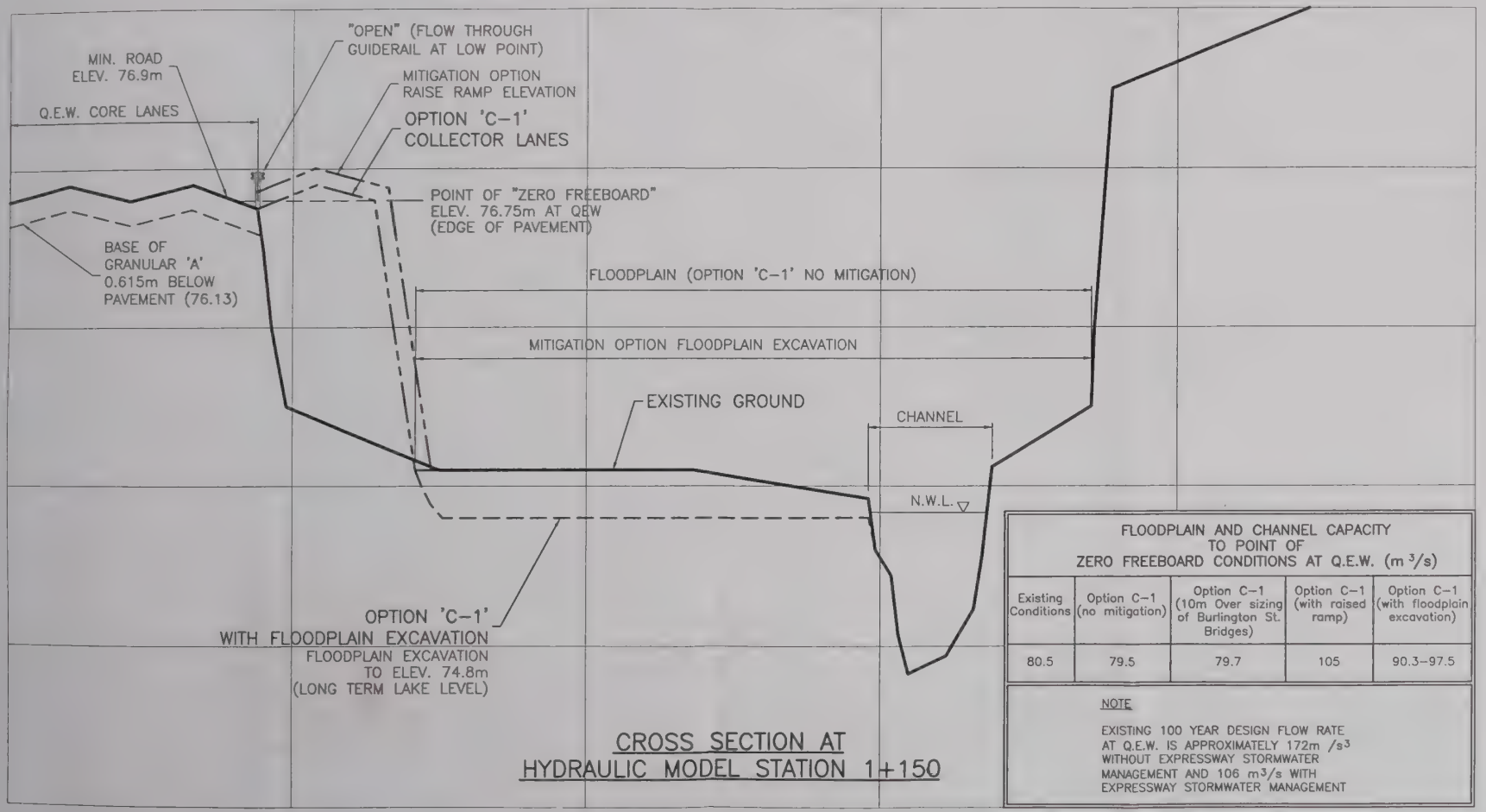
RED HILL CREEK EXPRESSWAY

CULVERT OPTIONS

SCALE: N.T.S. | FIGURE 3

RED HILL CREEK EXPRESSWAY AND BURLINGTON STREET

Q.E.W. INTERCHANGES



CROSS SECTION AT
HYDRAULIC MODEL STATION 1+150

FLOODPLAIN AND CHANNEL CAPACITY
TO POINT OF
ZERO FREEBOARD CONDITIONS AT Q.E.W. (m^3/s)

Existing Conditions	Option C-1 (no mitigation)	Option C-1 (10m Over sizing of Burlington St. Bridges)	Option C-1 (with raised ramp)	Option C-1 (with floodplain excavation)
80.5	79.5	79.7	105	90.3-97.5

NOTE

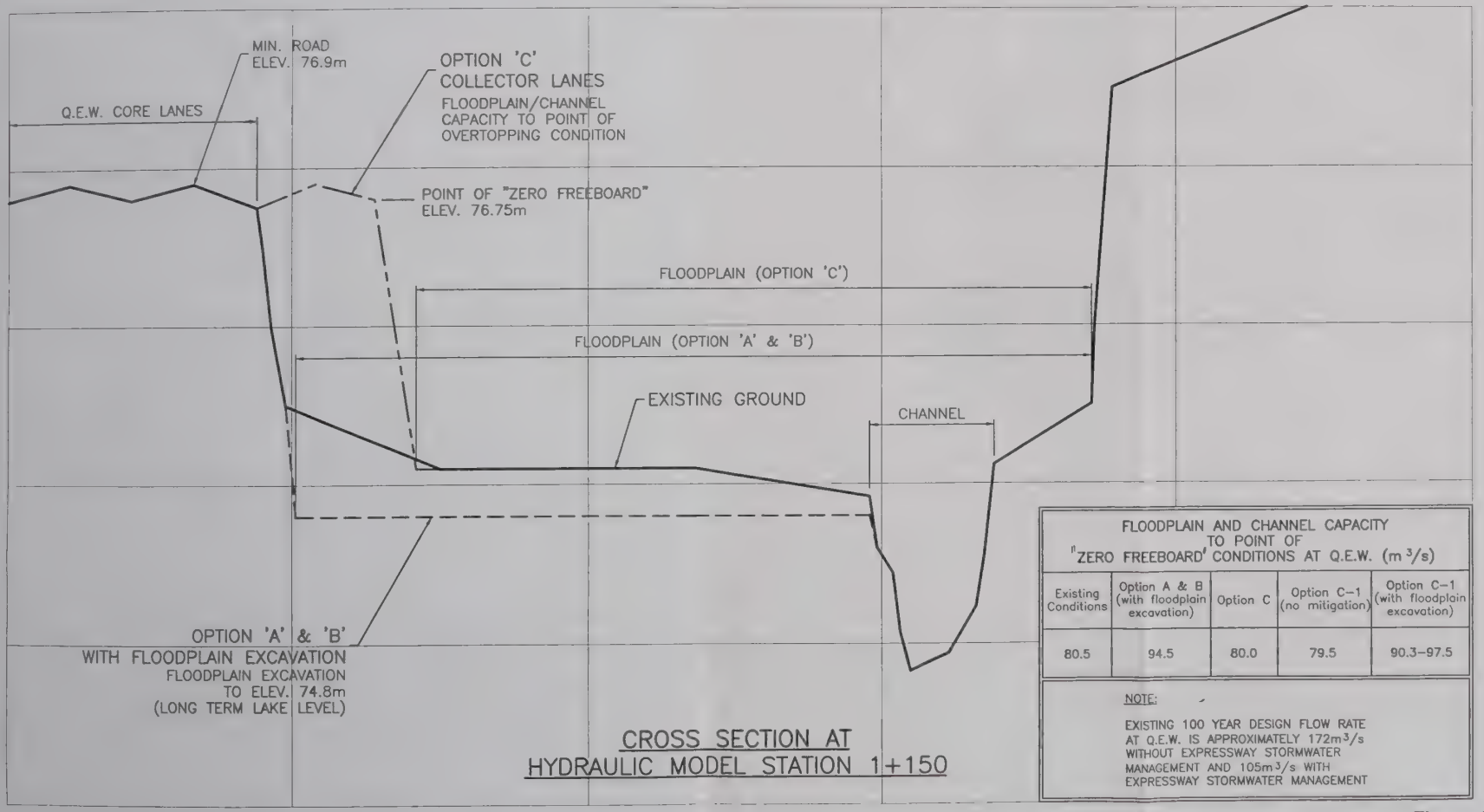
EXISTING 100 YEAR DESIGN FLOW RATE AT Q.E.W. IS APPROXIMATELY 172m $/s^3$ WITHOUT EXPRESSWAY STORMWATER MANAGEMENT AND 106 m^3/s WITH EXPRESSWAY STORMWATER MANAGEMENT

Figure 10

RED HILL CREEK EXPRESSWAY

IMPACT PREDICTION & MITIGATION
Q.E.W. TO BRAMPTON STREET

SURFACE WATER – FLOOD LEVELS



CROSS SECTION AT
HYDRAULIC MODEL STATION 1+150

FLOODPLAIN AND CHANNEL CAPACITY TO POINT OF "ZERO FREEBOARD" CONDITIONS AT Q.E.W. (m^3/s)				
Existing Conditions	Option A & B (with floodplain excavation)	Option C	Option C–1 (no mitigation)	Option C–1 (with floodplain excavation)
80.5	94.5	80.0	79.5	90.3–97.5

NOTE:

EXISTING 100 YEAR DESIGN FLOW RATE AT Q.E.W. IS APPROXIMATELY $172m^3/s$ WITHOUT EXPRESSWAY STORMWATER MANAGEMENT AND $105m^3/s$ WITH EXPRESSWAY STORMWATER MANAGEMENT

Figure 11

APPENDIX A
HYDRAULIC STRUCTURE SUMMARY

Hydraulic Structure Inventory

TABLE B.1

HYDRAULIC STRUCTURES SUMMARY

LOCATION	Struct. No.	Configuration & Dimensions	Invert U/S (m)	Top of Road (m)	Source	CAPACITY (m^3/s)			
						Freeboard (1m to E/P)	Clearance (1 m)	HW/D (1.5)	Overtop
WOODWARD AVE RED HILL CREEK	1	BRIDGE 30.1 x 3.83 SPAN = 30.1 LENGTH = 14.0	73.33	77.06	PP+E 1	N/A	66.0 [2 year]	N/A	395.0 [100 year]
RAMP – QEW TO WOODWARD AVE RED HILL CREEK	2	BRIDGE 48.0 x 5.15 SPAN = 65.0 LENGTH = 10.0	73.64	80.25	PP+E 1	N/A	430.0 [100 year]	N/A	1340.0 [Regional]
RAMP – BURLINGTON ST TO QEW RED HILL CREEK	3	BRIDGE 48.0 x 5.15 SPAN = 29.6 LENGTH = 37.0	73.34	78.72	PP+E 1	N/A	54.0 [2 year]	N/A	400.0 [100 year]
QEW – E/B AND W/B (0+970) RED HILL CREEK	3A	U/S & D/S CULVERT 3.3 x 1.6 C.S.P. ARCH LENGTH = 20.0 CULVERT UNDER QEW CONCRETE BOX LENGTH = 30.0 HEIGTH = 2.25	74.25 74.20	76.80	PP+E 4	culvert flow 15.0 (0.3 m) 14.0 (0.5 m)] channel flow 75.0 (0.3 m) 60.0 (0.5 m)	N/A N/A	N/A N/A	culvert flow 17.0 channel flow 95.0]
CNR (EAST) RED HILL CREEK	4A	CULVERT CONCRETE ARCH 3.9 x 3.4, SPAN = 3.9 LENGTH = 29.0	75.08	85.30	PP+E 1	140.0 [20 year]	55.0 [2 year]	110.0 [10 year]	170.0 [100 year]
CNR (WEST) RED HILL CREEK	4B	CULVERT CONCRETE ARCH U/S 3.9 x 3.63 D/S 4.2 x 3.77 SPAN = 3.9 LENGTH = 37.0	74.48	85.40	PP+E 1	140.0 [20 year]	55.0 [2 year]	110.0 [10 year]	170.0 [100 year]
BARTON STREET RED HILL CREEK	5	CULVERT TRIPLE CONCRET BOX 3.1 X 2.61 SPAN = 9.8 LENGTH = 83.0	76.05	83.69	PP+E 1	110.0 [10 year]	30.0 [1 year]	80.0 [5 year]	120.0 [20 year]
MELVIN AVENUE RED HILL CREEK	6	BRIDGE 14.0 x 2.8 SPAN = 14.0 LENGTH = 9.3	76.16	80.28	PP+E 1	N/A	25.0 [1 year]	N/A	85.0 [5 year]
QUEENSTON ROAD RED HILL CREEK	7	BRIDGE SPAN = 105.5 LENGTH = 31.91 Concrete Trapezoidal Channel 11.0 x 2.61	80 93	93.45	DWGS HEC-2	Channel Capacity 148.0 (0.3 m) [50 year]	N/A	N/A	Channel Capacity 154.08 [100 year]
KING STREET RED HILL CREEK	8	CULVERT Triple Box Culvert 4.6 x 3.3 SPAN = 15.6 LENGTH = 60.0	86.00	96.18	PP+E 2 DWGS HEC-2	N/A	20.0 [1 year]	104.0 [10 year]	85.0** [5 year]

TABLE B.1 (CONTINUED)

HYDRAULIC STRUCTURES SUMMARY

LOCATION	Str uct No.	Configuration & Dimensions	Invert U/S (m)	Top of Road (m)	Source	CAPACITY (m^3/s)			
						Freeboard (1m to E/P)	Clearance (1 m)	HW/D (1.5)	Overtop
PEDESTRIAN CROSSING (6+150) RED HILL CREEK	9	FOOTBRIDGE SPAN = 8.3 LENGTH = 1.6	88.22	92.14	PP+E 1	N/A	55.0 [2 year]	N/A	96.0 [20 year]
TH & B (CNR) RED HILL CREEK	10	CULVERT Triple Concrete Box 3.1 x 2.82 SPAN = 10.9 LENGTH = 60.0	88.86	105.70	PP+E 1	N/A	40.0 [2 year]	85.0 [20 year]	90.0** [20 year]
KING'S FOREST GOLF COURSE (7+895) RED HILL CREEK	11	FOOTBRIDGE SPAN = 6.4 LENGTH = -2.1	102.33	104.40	PP+E 1	N/A	13.0 [1 year]	N/A	39.0 [20 year]
KING'S FOREST GOLF COURSE (8+035) RED HILL CREEK	12	FOOTBRIDGE SPAN = 7.8 LENGTH = 2.1	104.4	106.27	PP+E 1	N/A	18.0 [1 year]	N/A	55.0 [100 year]
KING'S FOREST GOLF COURSE (8+376) RED HILL CREEK	13	FOOTBRIDGE SPAN = 5.8 LENGTH = 2.1	109.20	111.98	PP+E 1	N/A	20.0 [2 year]	N/A	43.0 [20 year]
KING'S FOREST GOLF COURSE (8+804) RED HILL CREEK	14	MAINTENANCE BRIDGE SPAN = 9.95 LENGTH = 8.4	118.03	121.72	PP+E 1	N/A	80.0 [100 year]	N/A	132.0 [100 year]
KING'S FOREST GOLF COURSE (8+906)	15	FOOTBRIDGE SPAN = 7.9 LENGTH = 2.1	120.01	123.66	PP+E 1	N/A	49.0 [50 year]	N/A	134.0 [100 year]
MOUNTAINBROW BOULEVARD RED HILL CREEK	17	CULVERT CONCRETE ARCH 6.9 x 4.1 SPAN = 6.9 LENGTH = 15.6	174.93	179.61	PP+E 1	24.0 [2 year]	15.0 [1 year]	N/A	45.0 [50 year]
C.N.R.	18	CULVERT CONCRETE ARCH 6.1 x 4.4 LENGTH = 19.2	180.41	189.60	PP+E 1	135.0 [Regional]	202.0 [Regional]	N/A	320.0 [Regional]
DARTNALL RD INTERCHANGE RAMP DARTNALL S – RHCE W RED HILL CREEK	24	CULVERT CONCRETE ARCH 14.0 x 7.0 LENGTH = 77.0	179.98	189.36	SPO 1	276.0 [Regional]	202.0 [Regional]	N/A	320.0 [Regional]
DARTNALL RD INTERCHANGE RAMP WB/EB LANES OF RHCE RED HILL CREEK	25	CULVERT CONCRETE BOX 14.0 x 2.3 LENGTH = 77.0	180.60	187.24	SPO 1	184.0 [100 year]	9.0 [1 year]	86.0 [100 year]	210.0 [Regional]
DARTNALL RD INTERCHANGE RAMP RHCE W TO DARTNALL S AND DARTNALL RD N/S RED HILL CREEK	26	CULVERT CONCRETE ARCH 14.0 x 7.0 LENGTH = 84.0	180.92	193.32	SPO 1	300.0 [Regional]	174.0 [100 year]	280.0 [Regional]	330.0 [Regional]

SOURCE NOTES

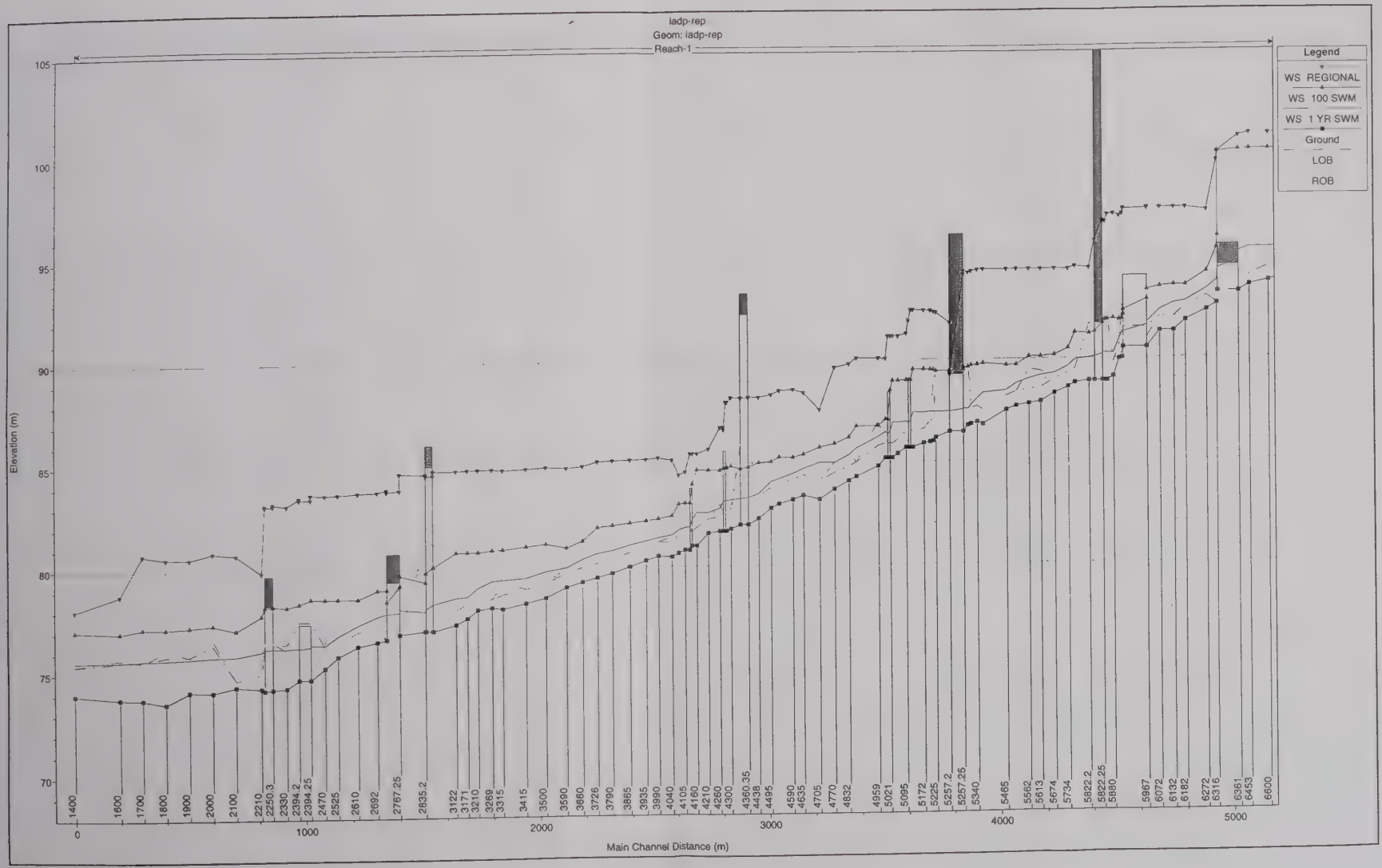
PP+E 1	Philips Planning and Engineering , Mountain East – West and North–South Transportation Corridor Drainage Study Phase II, November 1988.
PP+E 2	Philips Planning and Engineering, Mountain East – West and North-South Transportation Corridor Drainage Study - Final Report, July 1989.
PP+E 3	Philips Planning and Engineering, Site Inspection – June 1997.
PP+E 4	Philips Planning and Engineering, Hydraulic Analysis of Proposed Red Hill Creek Expressway/QEW Interchange, May 1990.
SPO 1	Special Projects Office, Dartnall Road Interchange – Grading, Drainage and Structures Drawings (Philips Planning and Engineering, 1995).
SPO 2	Special Projects Office, Stone Church Road Reconstruction – Grading and Structures Drawings (Philips Planning and Engineering, 1996).
CH	City of Hamilton, Sanitary and Storm Sewer Information
HEC-2	Philips Planning and Engineering, HEC-2 Data Sets – 1997.
DWGS	Fenco Engineers Inc., Grading and Drainage Plans
*	Approximate elevation estimated from topographic information
**	Flow at point of spill through roadway opening

APPENDIX B

RED HILL CREEK EXPRESSWAY
(MUD ST. TO BRAMPTON ST. SECTION)

HYDRAULIC MODEL RESULTS

EXISTING CONDITIONS


iadp-rep
Geom: iadp-rep
Reach-1
Legend
WS REGIONAL
WS 100 SWM
WS 1 YR SWM
Ground
LOB
ROB
Elevation (m)
Main Channel Distance (m)
105
100
95
90
85
80
75
70
0
1000
2000
3000
4000
5000
1400
1600
1700
1800
1900
2000
2100
2210
2250.3
2330
2394.2
2394.25
2470
2525
2610
2692
2767.25
2835.2
3122
3171
3210
3269
3315
3415
3500
3590
3680
3726
3790
3865
3935
3990
4040
4105
4160
4210
4260
4300
4360.35
4438
4495
4590
4635
4705
4770
4832
4959
5021
5095
5172
5225
5257.2
5257.25
5340
5465
5562
5613
5674
5734
5822.2
5822.25
5880
5967
6072
6132
6182
6272
6316
6361
6453
6600

HEC-RAS Plan: adp River: RIVER 1 Reach: Reach-1

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	1600	12.00	73.84	75.60	74.49	75.62	0.000140	0.56	21.45	15.76	0.15
Reach-1	1600	171.00	73.84	77.40	76.53	77.98	0.001679	3.37	55.11	22.08	0.61
Reach-1	1600	148.00	73.84	77.80	76.32	78.14	0.000838	2.58	64.17	23.16	0.44
Reach-1	1600	120.00	73.84	77.62	76.05	77.87	0.000658	2.21	60.04	22.76	0.38
Reach-1	1600	100.00	73.84	77.30	75.85	77.51	0.000641	2.04	52.91	21.67	0.37
Reach-1	1600	81.10	73.84	77.10	75.63	77.26	0.000531	1.77	48.63	20.84	0.34
Reach-1	1600	101.00	73.84	77.35	75.86	77.56	0.000620	2.03	53.97	21.87	0.37
Reach-1	1600	21.40	73.84	75.70	74.71	75.74	0.000358	0.93	23.05	16.11	0.25
Reach-1	1600	492.00	73.84	78.83	78.83	81.00	0.003886	6.59	89.51	26.25	0.98
Reach-1	1700	12.00	73.81	75.62		75.63	0.000121	0.48	25.12	21.82	0.14
Reach-1	1700	171.00	73.81	77.86		78.11	0.000627	2.23	99.84	41.37	0.39
Reach-1	1700	148.00	73.81	78.04		78.21	0.000390	1.82	107.54	41.98	0.31
Reach-1	1700	120.00	73.81	77.80		77.92	0.000329	1.60	97.27	41.16	0.28
Reach-1	1700	100.00	73.81	77.45		77.57	0.000333	1.49	83.34	40.02	0.28
Reach-1	1700	81.10	73.81	77.22		77.30	0.000292	1.32	73.91	39.22	0.26
Reach-1	1700	101.00	73.81	77.50		77.61	0.000322	1.48	85.19	40.17	0.27
Reach-1	1700	21.40	73.81	75.75		75.78	0.000272	0.77	28.00	22.73	0.22
Reach-1	1700	492.00	73.81	80.77		81.29	0.000602	3.31	233.54	48.50	0.42
Reach-1	1800	12.00	73.61	75.63		75.65	0.000164	0.61	19.70	14.21	0.17
Reach-1	1800	171.00	73.61	77.80		78.25	0.001239	3.05	86.23	37.41	0.52
Reach-1	1800	148.00	73.61	78.01		78.30	0.000758	2.48	93.86	38.04	0.41
Reach-1	1800	120.00	73.61	77.77		78.00	0.000631	2.17	85.04	37.31	0.37
Reach-1	1800	100.00	73.61	77.44		77.64	0.000632	2.02	72.71	36.23	0.37
Reach-1	1800	81.00	73.61	77.21		77.36	0.000545	1.79	64.48	35.26	0.34
Reach-1	1800	100.00	73.61	77.49		77.68	0.000598	1.99	74.45	36.43	0.36
Reach-1	1800	21.50	73.61	75.77		75.82	0.000395	0.99	21.70	14.55	0.26
Reach-1	1800	493.00	73.61	80.54		81.51	0.001312	4.64	212.62	57.64	0.59
Reach-1	1900	12.00	74.18	75.64		75.67	0.000260	0.68	17.66	15.61	0.20
Reach-1	1900	169.00	74.18	77.91		78.38	0.001254	3.06	65.29	26.32	0.53
Reach-1	1900	147.00	74.18	78.06		78.39	0.000816	2.54	69.32	26.99	0.43
Reach-1	1900	120.00	74.18	77.82		78.07	0.000695	2.24	62.87	25.91	0.40
Reach-1	1900	100.00	74.18	77.49		77.71	0.000694	2.08	54.55	24.44	0.39
Reach-1	1900	81.00	74.18	77.25		77.43	0.000605	1.84	48.93	23.32	0.36
Reach-1	1900	99.00	74.18	77.54		77.74	0.000645	2.03	55.71	24.66	0.38
Reach-1	1900	21.50	74.18	75.81		75.86	0.000553	1.06	20.23	16.01	0.30
Reach-1	1900	490.00	74.18	80.58		81.69	0.001405	4.79	151.19	38.13	0.62
Reach-1	2000	12.00	74.15	75.67		75.70	0.000335	0.76	15.79	14.25	0.23
Reach-1	2000	169.00	74.15	78.06		78.51	0.001286	3.00	62.58	27.00	0.53
Reach-1	2000	147.00	74.15	78.15		78.47	0.000885	2.53	65.08	27.66	0.44
Reach-1	2000	120.00	74.15	77.89		78.15	0.000777	2.25	58.17	25.75	0.41
Reach-1	2000	100.00	74.15	77.56		77.78	0.000795	2.11	50.07	23.20	0.41
Reach-1	2000	81.00	74.15	77.31		77.49	0.000716	1.88	44.59	21.54	0.38
Reach-1	2000	99.00	74.15	77.60		77.82	0.000740	2.05	51.04	23.52	0.39
Reach-1	2000	21.50	74.15	75.86		75.93	0.000672	1.16	18.58	14.98	0.33
Reach-1	2000	490.00	74.15	80.88		81.84	0.001222	4.44	167.59	47.68	0.58
Reach-1	2100	12.00	74.38	75.71		75.74	0.000414	0.75	16.01	17.46	0.25
Reach-1	2100	169.00	74.38	78.30		78.63	0.000839	2.56	78.92	29.85	0.44
Reach-1	2100	147.00	74.38	78.31		78.55	0.000629	2.22	79.20	29.89	0.38
Reach-1	2100	120.00	74.38	78.02		78.22	0.000564	1.99	70.79	28.68	0.36
Reach-1	2100	100.00	74.38	77.68		77.86	0.000575	1.86	61.35	27.26	0.35
Reach-1	2100	81.00	74.38	77.42		77.56	0.000527	1.67	54.29	26.17	0.33
Reach-1	2100	99.00	74.38	77.72		77.88	0.000542	1.82	62.27	27.40	0.34
Reach-1	2100	21.50	74.38	75.94		76.00	0.000673	1.07	20.24	19.08	0.33
Reach-1	2100	490.00	74.38	81.23		81.96	0.000848	3.89	184.34	42.15	0.49
Reach-1	2250	12.00	74.09	75.76		75.80	0.000373	0.79	15.11	13.82	0.24
Reach-1	2250	169.00	74.09	78.36		78.81	0.001136	2.96	63.67	23.50	0.51
Reach-1	2250	147.00	74.09	78.36		78.69	0.000867	2.58	63.47	23.47	0.44
Reach-1	2250	120.00	74.09	78.07		78.34	0.000772	2.30	56.91	22.42	0.41
Reach-1	2250	100.00	74.09	77.74		77.97	0.000775	2.14	49.75	21.22	0.41
Reach-1	2250	81.00	74.09	77.48		77.66	0.000705	1.92	44.27	20.25	0.38
Reach-1	2250	99.00	74.09	77.77		77.99	0.000734	2.10	50.37	21.32	0.40
Reach-1	2250	21.50	74.09	76.03		76.10	0.000623	1.14	18.92	14.73	0.32
Reach-1	2250	490.00	74.09	81.15		82.21	0.001274	4.64	143.50	33.67	0.59
Reach-1	2330	12.00	74.56	75.80		75.83	0.000491	0.83	14.52	15.34	0.27
Reach-1	2330	169.00	74.56	78.55		78.89	0.000842	2.62	76.20	27.34	0.45

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	2330	147 00	74.56	78.49		78.76	0.000676	2.32	74.55	27.17	0.40
Reach-1	2330	120.00	74.56	78.18		78.40	0.000620	2.09	66.25	26.28	0.38
Reach-1	2330	100 00	74.56	77.84		78.03	0.000631	1.95	57.55	25.31	0.37
Reach-1	2330	81 00	74.56	77.56		77.72	0.000591	1.76	50.56	24.51	0.35
Reach-1	2330	99 00	74.56	77.87		78.05	0.000601	1.92	58.16	25.38	0.36
Reach-1	2330	21 50	74.56	76.08		76.15	0.000690	1.12	19.22	16.86	0.33
Reach-1	2330	490 00	74.56	81.54		82.33	0.000873	4.02	172.42	38.26	0.50
Reach-1	2334.2	12 00	74.71	75.78	75.54	75.88	0.000607	1.34	8.97	14.40	0.54
Reach-1	2334.2	169 00	74.71	78.84	77.40	78.93	0.000098	1.35	125.51	57.32	0.27
Reach-1	2334.2	147 00	74.71	78.71	77.30	78.79	0.000089	1.23	119.06	56.86	0.26
Reach-1	2334.2	120 00	74.71	78.35	77.18	78.42	0.000103	1.19	100.85	55.56	0.27
Reach-1	2334.2	100 00	74.71	77.99	76.90	78.06	0.000141	1.22	82.30	54.24	0.30
Reach-1	2334.2	81 00	74.71	77.67	76.69	77.74	0.000191	1.22	66.18	53.16	0.34
Reach-1	2334.2	99.00	74.71	78.00	76.89	78.08	0.000133	1.19	83.23	54.31	0.30
Reach-1	2334.2	21.50	74.71	76.07	75.77	76.20	0.000618	1.62	13.26	15.69	0.56
Reach-1	2334.2	490.00	74.71	82.28	78.47	82.40	0.000042	1.57	378.81	97.00	0.21
Reach-1	2334.25	Bndge									
Reach-1	2334.3	12.00	74.46	76.27	75.51	76.29	0.000097	0.60	19.93	26.80	0.22
Reach-1	2334.3	169.00	74.46	85.71	77.09	85.71	0.000001	0.32	726.98	97.05	0.03
Reach-1	2334.3	147.00	74.46	85.53	76.98	85.53	0.000001	0.28	710.01	97.04	0.03
Reach-1	2334.3	120.00	74.46	85.62	76.84	85.62	0.000000	0.23	718.69	97.05	0.02
Reach-1	2334.3	100.00	74.46	85.42	76.70	85.42	0.000000	0.19	699.34	97.04	0.02
Reach-1	2334.3	81 00	74.46	82.89	76.55	82.89	0.000001	0.23	345.93	97.01	0.03
Reach-1	2334.3	99.00	74.46	85.39	76.69	85.39	0.000000	0.19	696.63	97.04	0.02
Reach-1	2334.3	21.50	74.46	76.88	75.76	76.89	0.000053	0.51	42.00	46.16	0.17
Reach-1	2334.3	490.00	74.46	87.11	78.17	87.14	0.000004	0.79	863.67	97.06	0.08
Reach-1	2334.4	12.00	74.49	76.25		76.30	0.000720	0.98	17.84	17.89	0.31
Reach-1	2334.4	172 00	74.49	84.00		84.01	0.000019	0.66	1123.88	215.01	0.07
Reach-1	2334.4	151 00	74.49	83.90		83.91	0.000016	0.59	1102.26	215.01	0.07
Reach-1	2334.4	123 00	74.49	83.70		83.71	0.000011	0.50	1059.66	215.00	0.06
Reach-1	2334.4	104 00	74.49	85.42		85.42	0.000004	0.32	1429.36	215.03	0.03
Reach-1	2334.4	84.30	74.49	82.89		82.89	0.000007	0.37	901.47	169.34	0.04
Reach-1	2334.4	97 90	74.49	83.70		83.71	0.000007	0.39	1059.66	215.00	0.04
Reach-1	2334.4	21 40	74.49	76.85		76.90	0.000572	1.04	30.21	23.44	0.29
Reach-1	2334.4	489 00	74.49	85.40		85.45	0.000080	1.49	1424.70	215.03	0.15
Reach-1	2470	12 00	74.58	76.29		76.32	0.000307	0.72	16.74	16.02	0.22
Reach-1	2470	172 00	74.58	84.00		84.01	0.000018	0.70	914.04	136.99	0.08
Reach-1	2470	151 00	74.58	83.90		83.91	0.000015	0.63	900.32	136.69	0.07
Reach-1	2470	123.00	74.58	83.70		83.71	0.000011	0.52	873.35	136.10	0.06
Reach-1	2470	104 00	74.58	85.42		85.42	0.000004	0.37	1221.55	265.01	0.04
Reach-1	2470	84 30	74.58	82.89		82.89	0.000007	0.40	764.44	132.17	0.05
Reach-1	2470	97 90	74.58	83.70		83.71	0.000007	0.42	873.37	136.10	0.05
Reach-1	2470	21 40	74.58	76.89		76.92	0.000217	0.80	38.73	64.73	0.20
Reach-1	2470	489.00	74.58	85.38		85.47	0.000093	1.76	1210.52	265.01	0.18
Reach-1	2570	12 00	74.95	76.31		76.39	0.001123	1.27	16.11	34.49	0.40
Reach-1	2570	172 00	74.95	84.01		84.02	0.000026	0.73	1026.25	160.04	0.08
Reach-1	2570	151 00	74.95	83.90		83.91	0.000021	0.65	1010.02	159.52	0.07
Reach-1	2570	123 00	74.95	83.70		83.71	0.000015	0.54	978.34	158.52	0.06
Reach-1	2570	104 00	74.95	85.42		85.42	0.000007	0.42	1354.64	272.01	0.04
Reach-1	2570	84 30	74.95	82.89		82.89	0.000011	0.42	851.12	154.73	0.05
Reach-1	2570	97.90	74.95	83.70		83.71	0.000010	0.43	978.16	158.52	0.05
Reach-1	2570	21 40	74.95	76.90		76.96	0.000660	1.21	52.94	87.37	0.31
Reach-1	2570	489 00	74.95	85.40		85.48	0.000158	1.97	1348.74	272.01	0.20
Reach-1	2670	12 00	74.83	76.41		76.45	0.000384	0.85	14.14	11.39	0.24
Reach-1	2670	172 00	74.83	84.01		84.02	0.000013	0.54	1517.43	245.47	0.06
Reach-1	2670	151 00	74.83	83.91		83.91	0.000011	0.49	1492.19	244.83	0.05
Reach-1	2670	123 00	74.83	83.71		83.71	0.000008	0.41	1443.13	243.78	0.05
Reach-1	2670	104 00	74.83	85.42		85.42	0.000003	0.30	1937.72	351.77	0.03
Reach-1	2670	84 30	74.83	82.89		82.90	0.000006	0.32	1246.35	239.55	0.04
Reach-1	2670	97 90	74.83	83.71		83.71	0.000005	0.33	1442.51	243.77	0.04
Reach-1	2670	21 40	74.83	76.96		77.01	0.000398	1.03	25.56	40.09	0.25
Reach-1	2670	489 00	74.83	85.46		85.49	0.000070	1.40	1949.21	351.87	0.14
Reach-1	2750	12 00	75.32	76.42		76.54	0.002279	1.55	7.72	10.02	0.57
Reach-1	2750	172 00	75.32	84.01		84.02	0.000011	0.49	1638.48	253.35	0.06

HEC-RAS Plan: jadb River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	2750	151 00	75 32	83 91		83 91	0 000009	0 44	1612 30	252 93	0 03
Reach-1	2750	123 00	75 32	83 71		83 71	0 000006	0.37	1561.47	252 08	0 04
Reach-1	2750	104 00	75 32	85 42		85 43	0 000002	0.25	2025.96	352 95	0 03
Reach-1	2750	84 30	75 32	82 89		82 90	0.000005	0.29	1357.49	248 71	0 04
Reach-1	2750	97 90	75 32	83 71		83 71	0.000004	0.30	1560.71	252 07	0 03
Reach-1	2750	21 40	75 32	76 96		77 09	0.001365	1.56	13.72	11 85	0 46
Reach-1	2750	489 00	75 32	85 48		85 50	0.000047	1.15	2044.86	361 05	0 12
Reach-1	2830	12 00	75 80	76 63		76 71	0.001966	1.30	9.26	14.25	0.51
Reach-1	2830	172 00	75 80	84 01		84 02	0 000017	0.61	1195.46	196.44	0.07
Reach-1	2830	151 00	75 80	83 91		83 92	0.000014	0.55	1175.25	196.12	0.06
Reach-1	2830	123 00	75 80	83 71		83 71	0.000010	0.46	1135.93	195.49	0.05
Reach-1	2830	104 00	75 80	85 42		85 43	0.000003	0.30	1476.36	201.70	0.03
Reach-1	2830	84 30	75 80	82 89		82 90	0.000007	0.37	977.79	192.86	0.04
Reach-1	2830	97 90	75 80	83 71		83 71	0.000006	0.37	1135.42	195.49	0.04
Reach-1	2830	21 40	75 80	77 10		77 19	0.001085	1.31	16.30	15.95	0.41
Reach-1	2830	489 00	75 80	85.47		85 51	0.000072	1.42	1484.76	201.86	0.15
Reach-1	2835.1	12 00	75.76	76.76		76 87	0.002218	1.49	8.05	9.80	0.52
Reach-1	2835.1	172.00	75.76	83.99		84 03	0.000083	1.21	500.23	90.96	0.14
Reach-1	2835.1	151.00	75.76	83.89		83 93	0.000067	1.08	491.29	90.51	0.12
Reach-1	2835.1	123 00	75 76	83.70		83 72	0.000049	0.91	473.64	89.63	0.10
Reach-1	2835.1	104 00	75 76	85.42		85 43	0.000016	0.60	633.71	97.77	0.06
Reach-1	2835.1	84 30	75.76	82.89		82 90	0.000035	0.72	402.54	85.93	0.09
Reach-1	2835.1	97 90	75.76	83 70		83.71	0.000031	0.72	473.81	89.64	0.08
Reach-1	2835.1	21 40	75.76	77.15		77 32	0.002095	1.80	11.90	9.80	0.52
Reach-1	2835.1	489.00	75 76	85 35		85.57	0.000367	2.84	626.97	97.15	0.30
Reach-1	2835.2	12 00	76.05	76.94	76 58	77 04	0.001721	1.37	8.73	9.80	0.46
Reach-1	2835.2	172 00	76 05	84 02	79 20	84 04	0.000040	0.76	303.55	180.22	0.09
Reach-1	2835.2	151.00	76 05	83.91	78 94	83 93	0.000035	0.70	285.37	162.17	0.08
Reach-1	2835.2	123.00	76.05	83 71	78.57	83 72	0.000026	0.60	256.50	122.39	0.07
Reach-1	2835.2	104.00	76 05	85 43	78 30	85 43	0.000003	0.21	614.20	252.14	0.02
Reach-1	2835.2	84.30	76.05	82 85	78 01	82 93	0.000138	1.27	66.58	68.90	0.16
Reach-1	2835.2	97 90	76 05	83 71	78 22	83 72	0.000017	0.48	256.05	121.68	0.06
Reach-1	2835.2	21 40	76.05	77 33	76.83	77 48	0.001775	1.70	12.56	9.80	0.48
Reach-1	2835.2	489 00	76.05	85 57	82.37	85 60	0.000048	0.94	650.46	256.99	0.10
Reach-1	2835.25	Bridge									
Reach-1	2835.3	12 00	76 05	77 16	76.58	77 22	0.000882	1.11	10.83	9.80	0.34
Reach-1	2835.3	172 00	76.05	84 63	79 20	84 64	0.000018	0.54	425.31	217.36	0.06
Reach-1	2835.3	151.00	76.05	84 55	78 94	84 56	0.000015	0.49	408.39	212.95	0.05
Reach-1	2835.3	123 00	76.05	84 42	78 57	84 43	0.000012	0.43	381.16	205.20	0.05
Reach-1	2835.3	104 00	76.05	85 44	78 30	85 44	0.000003	0.21	615.99	252.38	0.02
Reach-1	2835.3	84 30	76 05	83 97	78 01	83 98	0.000010	0.38	295.60	174.10	0.04
Reach-1	2835.3	97 90	76 05	84 32	78.22	84 32	0.000009	0.37	359.56	198.56	0.04
Reach-1	2835.3	21 40	76 05	77 60	76 83	77 70	0.000996	1.41	15.20	9.80	0.36
Reach-1	2835.3	489 00	76 05	85 64	82 37	85 67	0.000044	0.91	668.71	259.46	0.09
Reach-1	2835.4	12 00	75 64	77 19		77 22	0.000460	0.89	15.12	13.67	0.25
Reach-1	2835.4	172 00	75 64	84 62		84 65	0.000053	1.06	448.50	216.53	0.11
Reach-1	2835.4	151 00	75 64	84 54		84 57	0.000044	0.95	432.20	212.27	0.10
Reach-1	2835.4	123 00	75 64	84 41		84 43	0.000032	0.81	405.73	204.64	0.09
Reach-1	2835.4	104 00	75 64	85 43		85 44	0.000009	0.47	641.75	252.29	0.05
Reach-1	2835.4	84 30	75 64	83 97		83 98	0.000022	0.65	320.96	173.25	0.07
Reach-1	2835.4	97 90	75 64	84 31		84 32	0.000022	0.67	384.74	198.18	0.07
Reach-1	2835.4	21 40	75 64	77 65		77 71	0.000517	1.13	21.72	15.25	0.27
Reach-1	2835.4	489 00	75 64	85 59		85 69	0.000181	2.10	682.63	257.77	0.21
Reach-1	3025	12 00	76 01	77 20		77 24	0.000739	0.96	12.46	14.33	0.33
Reach-1	3025	172 00	76 01	84 63		84 65	0.000027	0.80	519.33	216.90	0.09
Reach-1	3025	151 00	76 01	84 55		84 57	0.000022	0.72	502.59	212.89	0.08
Reach-1	3025	123 00	76 01	84 42		84 43	0.000016	0.61	475.50	205.76	0.07
Reach-1	3025	104 00	76 01	85 43		85 44	0 000005	0.38	709.28	252.08	0.04
Reach-1	3025	84 30	76.01	83.98		83.98	0 000011	0.48	389.46	178.13	0 06
Reach-1	3025	97 90	76 01	84 32		84 32	0.000011	0.50	453.91	199.63	0.06
Reach-1	3025	21 40	76 01	77 67		77 73	0 000604	1.10	19.45	15.48	0.31
Reach-1	3025	489 00	76 01	85 62		85 70	0 000104	1 71	756.16	258 93	0 18
Reach-1	3026.2	12 00	76 06	77 24	76 48	77 26	0.000328	0 73	16 48	14.00	0 21
Reach-1	3026.2	172 00	76.06	84.65	78 54	84 65	0 000009	0.41	945.79	232 78	0 04

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	3026.2	151.00	76.06	84.57	78.34	84.57	0.000008	0.37	926.89	230.98	0 04
Reach-1	3026.2	123.00	76.06	84.43	78.05	84.44	0.000006	0.31	896.21	228.04	0.03
Reach-1	3026.2	104.00	76.06	85.44	77.84	85.44	0.000002	0.21	1135.94	248.39	0.02
Reach-1	3026.2	84.30	76.06	83.98	77.61	83.98	0.000004	0.24	795.79	218.21	0.03
Reach-1	3026.2	97.90	76.06	84.32	77.76	84.32	0.000004	0.25	871.20	225.62	0.03
Reach-1	3026.2	21.40	76.06	77.70	76.68	77.75	0.000370	0.93	23.00	14.00	0.23
Reach-1	3026.2	489.00	76.06	85.69	80.70	85.71	0.000040	0.92	1199.57	253.15	0.09
Reach-1	3026.3	12.00	76.06	77.24		77.26	0.000328	0.73	16.48	14.00	0.21
Reach-1	3026.3	172.00	76.06	84.65		84.65	0.000002	0.17	946.19	232.82	0.02
Reach-1	3026.3	151.00	76.06	84.57		84.57	0.000001	0.15	927.21	231.02	0.02
Reach-1	3026.3	123.00	76.06	84.43		84.44	0.000001	0.13	896.44	228.06	0.01
Reach-1	3026.3	104.00	76.06	85.44		85.44	0.000000	0.08	1136.03	248.40	0.01
Reach-1	3026.3	84.30	76.06	83.98		83.98	0.000001	0.10	795.93	218.22	0.01
Reach-1	3026.3	97.90	76.06	84.32		84.32	0.000001	0.11	871.36	225.63	0.01
Reach-1	3026.3	21.40	76.06	77.70		77.75	0.000369	0.93	23.00	14.00	0.23
Reach-1	3026.3	489.00	76.06	85.70		85.71	0.000007	0.37	1201.46	253.29	0.04
Reach-1	3026.35	Bridge									
Reach-1	3026.4	12.00	76.06	77.24	76.48	77.27	0.000325	0.73	16.53	14.00	0.21
Reach-1	3026.4	172.00	76.06	84.66	79.15	84.66	0.000002	0.17	947.30	232.92	0.02
Reach-1	3026.4	151.00	76.06	84.57	78.34	84.57	0.000001	0.15	928.10	231.10	0.02
Reach-1	3026.4	123.00	76.06	84.44	78.05	84.44	0.000001	0.13	897.08	228.13	0.01
Reach-1	3026.4	104.00	76.06	85.44	77.83	85.44	0.000000	0.08	1136.30	248.42	0.01
Reach-1	3026.4	84.30	76.06	83.99	77.60	83.99	0.000001	0.10	796.31	218.25	0.01
Reach-1	3026.4	97.90	76.06	84.33	77.76	84.33	0.000001	0.11	871.79	225.67	0.01
Reach-1	3026.4	21.40	76.06	77.71	76.68	77.75	0.000367	0.93	23.05	14.00	0.23
Reach-1	3026.4	489.00	76.06	85.72	80.30	85.73	0.000007	0.37	1206.69	253.68	0.04
Reach-1	3026.5	12.00	76.06	77.24	76.48	77.27	0.000325	0.73	16.53	14.00	0.21
Reach-1	3026.5	172.00	76.06	84.64	78.54	84.66	0.000033	0.77	944.90	232.69	0.08
Reach-1	3026.5	151.00	76.06	84.56	78.34	84.58	0.000027	0.69	926.20	230.92	0.08
Reach-1	3026.5	123.00	76.06	84.43	78.04	84.44	0.000019	0.57	895.75	228.00	0.06
Reach-1	3026.5	104.00	76.06	85.44	77.83	85.44	0.000008	0.40	1135.66	248.37	0.04
Reach-1	3026.5	84.30	76.06	83.98	77.60	83.99	0.000012	0.43	795.56	218.19	0.05
Reach-1	3026.5	97.90	76.06	84.32	77.76	84.33	0.000013	0.47	870.91	225.59	0.05
Reach-1	3026.5	21.40	76.06	77.71	76.68	77.75	0.000367	0.93	23.06	14.00	0.23
Reach-1	3026.5	489.00	76.06	85.67	81.17	85.75	0.000155	1.80	1193.56	252.70	0.18
Reach-1	3170	12.00	75.95	77.25		77.37	0.002862	1.50	8.01	13.05	0.61
Reach-1	3170	166.00	75.95	84.66		84.66	0.000015	0.58	1288.91	261.98	0.07
Reach-1	3170	146.00	75.95	84.57		84.58	0.000012	0.51	1267.23	261.25	0.06
Reach-1	3170	121.00	75.95	84.44		84.44	0.000009	0.44	1231.92	260.06	0.05
Reach-1	3170	103.00	75.95	85.44		85.44	0.000004	0.31	1496.68	268.40	0.03
Reach-1	3170	84.30	75.95	83.99		83.99	0.000006	0.33	1115.35	256.08	0.04
Reach-1	3170	97.00	75.95	84.33		84.33	0.000006	0.36	1202.95	259.07	0.04
Reach-1	3170	20.90	75.95	77.73		77.83	0.001403	1.42	14.69	15.00	0.46
Reach-1	3170	486.00	75.95	85.72		85.76	0.000073	1.40	1571.98	270.56	0.15
Reach-1	3300	12.00	76.95	77.74		77.90	0.005988	1.80	6.68	14.91	0.86
Reach-1	3300	166.00	76.95	84.66		84.67	0.000013	0.50	1302.37	223.51	0.06
Reach-1	3300	146.00	76.95	84.58		84.58	0.000010	0.45	1283.68	223.14	0.05
Reach-1	3300	121.00	76.95	84.44		84.44	0.000007	0.38	1253.30	222.54	0.05
Reach-1	3300	103.00	76.95	85.44		85.44	0.000003	0.28	1478.03	226.94	0.03
Reach-1	3300	84.60	76.95	83.99		83.99	0.000005	0.29	1153.01	220.55	0.04
Reach-1	3300	91.80	76.95	84.33		84.33	0.000005	0.30	1228.35	222.04	0.04
Reach-1	3300	20.70	76.95	77.96		78.17	0.004860	2.05	10.09	15.61	0.81
Reach-1	3300	484.00	76.95	85.74		85.77	0.000063	1.25	1546.24	228.26	0.14
Reach-1	3400	12.00	76.44	78.08	77.67	78.17	0.001463	1.31	9.19	10.80	0.45
Reach-1	3400	166.00	76.44	84.66		84.67	0.000018	0.59	1048.39	194.57	0.07
Reach-1	3400	146.00	76.44	84.58		84.58	0.000015	0.53	1032.13	194.22	0.06
Reach-1	3400	121.00	76.44	84.44		84.44	0.000011	0.45	1005.69	193.65	0.06
Reach-1	3400	103.00	76.44	85.44		85.44	0.000005	0.32	1201.55	198.29	0.04
Reach-1	3400	84.60	76.44	83.99		83.99	0.000007	0.34	918.48	191.75	0.04
Reach-1	3400	91.80	76.44	84.33		84.33	0.000007	0.35	984.00	193.18	0.04
Reach-1	3400	20.70	76.44	78.33	77.94	78.48	0.002074	1.73	11.99	12.04	0.55
Reach-1	3400	484.00	76.44	85.74		85.78	0.000089	1.44	1260.91	199.84	0.16
Reach-1	3570	12.00	77.73	78.41		78.52	0.002903	1.46	8.20	14.11	0.61
Reach-1	3570	166.00	77.73	84.65		84.68	0.000042	0.88	658.70	121.00	0.11

HEC-RAS Plan: jadb River: RIVER 1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	3570	146.00	77.73	84.57		84.59	0.000034	0.78	648.74	120.76	0.10
Reach-1	3570	121.00	77.73	84.44		84.45	0.000025	0.66	632.47	120.37	0.08
Reach-1	3570	103.00	77.73	85.44		85.44	0.000011	0.48	754.76	124.63	0.06
Reach-1	3570	84.60	77.73	83.99		83.99	0.000016	0.50	578.47	119.06	0.07
Reach-1	3570	91.80	77.73	84.33		84.33	0.000015	0.51	619.15	120.05	0.06
Reach-1	3570	20.70	77.73	78.71		78.85	0.002240	1.64	12.61	14.78	0.57
Reach-1	3570	484.00	77.73	85.70		85.83	0.000210	2.17	787.27	126.19	0.25
Reach-1	3650	12.00	77.15	78.57		78.60	0.000481	0.81	14.82	16.26	0.27
Reach-1	3650	166.00	77.15	84.66		84.68	0.000028	0.73	808.36	159.76	0.09
Reach-1	3650	147.00	77.15	84.58		84.59	0.000023	0.66	794.92	159.57	0.08
Reach-1	3650	124.00	77.15	84.44		84.45	0.000018	0.57	773.08	159.27	0.07
Reach-1	3650	106.00	77.15	85.44		85.45	0.000008	0.41	933.37	161.47	0.05
Reach-1	3650	88.10	77.15	83.99		83.99	0.000012	0.44	701.16	158.27	0.06
Reach-1	3650	91.80	77.15	84.33		84.33	0.000010	0.43	755.24	159.02	0.05
Reach-1	3650	20.80	77.15	78.89		78.94	0.000576	1.03	20.28	17.74	0.31
Reach-1	3650	492.00	77.15	85.74		85.84	0.000140	1.81	982.44	162.14	0.21
Reach-1	3750	12.00	77.74	78.67	78.67	78.93	0.008228	2.27	5.30	10.14	1.00
Reach-1	3750	166.00	77.74	84.66		84.68	0.000058	0.98	624.89	127.71	0.13
Reach-1	3750	147.00	77.74	84.58		84.60	0.000048	0.88	614.24	127.39	0.11
Reach-1	3750	124.00	77.74	84.44		84.45	0.000037	0.76	596.90	126.87	0.10
Reach-1	3750	106.00	77.74	85.44		85.45	0.000015	0.55	725.72	130.76	0.07
Reach-1	3750	88.10	77.74	83.99		84.00	0.000025	0.60	539.92	125.15	0.08
Reach-1	3750	91.80	77.74	84.33		84.34	0.000022	0.58	582.80	126.45	0.08
Reach-1	3750	20.80	77.74	78.91	78.91	79.26	0.007544	2.65	7.86	11.03	1.00
Reach-1	3750	492.00	77.74	85.72		85.88	0.000284	2.42	762.88	131.89	0.29
Reach-1	3792	12.00	78.27	79.02		79.16	0.003529	1.66	7.24	12.09	0.68
Reach-1	3792	166.00	78.27	84.65		84.69	0.000069	1.07	506.86	110.10	0.14
Reach-1	3792	147.00	78.27	84.57		84.60	0.000057	0.96	497.77	109.89	0.13
Reach-1	3792	124.00	78.27	84.44		84.46	0.000044	0.84	482.91	109.54	0.11
Reach-1	3792	106.00	78.27	85.44		85.45	0.000018	0.59	593.99	112.40	0.07
Reach-1	3792	88.10	78.27	83.99		84.00	0.000030	0.65	433.76	108.36	0.09
Reach-1	3792	91.80	78.27	84.33		84.34	0.000026	0.63	470.86	109.25	0.08
Reach-1	3792	20.80	78.27	79.29		79.48	0.003320	1.93	10.80	13.67	0.69
Reach-1	3792	492.00	78.27	85.69		85.91	0.000336	2.63	622.79	113.22	0.32
Reach-1	3850	12.00	78.39	79.30		79.39	0.001543	1.29	9.32	12.10	0.47
Reach-1	3850	166.00	78.39	84.67		84.70	0.000071	1.10	568.79	130.40	0.14
Reach-1	3850	147.00	78.39	84.58		84.61	0.000059	0.99	557.73	129.99	0.13
Reach-1	3850	124.00	78.39	84.44		84.46	0.000046	0.86	539.87	129.33	0.11
Reach-1	3850	106.00	78.39	85.44		85.45	0.000018	0.60	671.08	132.97	0.07
Reach-1	3850	88.10	78.39	83.99		84.00	0.000032	0.68	481.68	127.15	0.09
Reach-1	3850	91.80	78.39	84.33		84.34	0.000027	0.65	525.27	128.79	0.09
Reach-1	3850	20.80	78.39	79.58		79.72	0.001695	1.63	12.96	16.51	0.51
Reach-1	3850	492.00	78.39	85.77		85.94	0.000327	2.63	714.57	133.69	0.31
Reach-1	3872	12.00	78.30	79.34		79.42	0.001826	1.29	9.29	13.59	0.50
Reach-1	3872	166.00	78.30	84.67		84.70	0.000056	0.93	579.97	135.74	0.12
Reach-1	3872	147.00	78.30	84.59		84.61	0.000046	0.84	568.28	135.27	0.11
Reach-1	3872	124.00	78.30	84.45		84.46	0.000036	0.73	549.50	134.52	0.10
Reach-1	3872	106.00	78.30	85.44		85.45	0.000014	0.51	685.92	139.19	0.06
Reach-1	3872	88.10	78.30	83.99		84.00	0.000025	0.57	488.80	132.06	0.08
Reach-1	3872	91.80	78.30	84.33		84.34	0.000021	0.55	534.05	133.90	0.08
Reach-1	3872	20.80	78.30	79.64		79.76	0.001812	1.50	13.84	15.95	0.51
Reach-1	3872	492.00	78.30	85.81		85.95	0.000250	2.21	736.93	140.57	0.27
Reach-1	3987	12.00	78.38	79.50		79.54	0.000628	0.90	13.26	14.76	0.30
Reach-1	3987	166.00	78.38	84.70		84.71	0.000030	0.68	907.93	205.82	0.09
Reach-1	3987	147.00	78.38	84.61		84.61	0.000025	0.62	889.38	205.32	0.08
Reach-1	3987	124.00	78.38	84.46		84.47	0.000019	0.54	859.98	204.53	0.07
Reach-1	3987	106.00	78.38	85.45		85.45	0.000008	0.37	1064.70	209.75	0.05
Reach-1	3987	88.10	78.38	84.00		84.01	0.000014	0.43	766.43	201.99	0.06
Reach-1	3987	91.80	78.38	84.34		84.34	0.000012	0.41	835.30	203.86	0.06
Reach-1	3987	20.80	78.38	79.82		79.89	0.000730	1.15	18.09	15.48	0.34
Reach-1	3987	492.00	78.38	85.93		85.98	0.000125	1.59	1165.20	212.13	0.19
Reach-1	4088	12.00	78.91	79.58	79.58	79.82	0.008259	2.17	5.52	11.80	1.01
Reach-1	4088	166.00	78.91	84.69		84.71	0.000062	0.96	727.25	187.66	0.13
Reach-1	4088	147.00	78.91	84.60		84.62	0.000052	0.87	710.45	187.13	0.12
Reach-1	4088	124.00	78.91	84.46		84.47	0.000041	0.76	683.79	186.26	0.11

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	4088	106 00	78.91	85.45		85.45	0.000015	0.51	870.74	191.21	0.07
Reach-1	4088	88.10	78 91	84.00		84 01	0.000030	0.61	598.82	183.50	0.09
Reach-1	4088	91 80	78.91	84.34		84.35	0.000025	0.58	661.48	185.54	0.08
Reach-1	4088	20 80	78 91	79.83	79.80	80.13	0.006512	2.43	8.58	13.12	0.95
Reach-1	4088	492 00	78.91	85.91		86.01	0.000243	2.16	959.32	192.96	0.27
Reach-1	4140	12 00	78 38	79.87		79.91	0.000447	0.83	14.43	13 99	0 26
Reach-1	4140	166 00	78 38	84.70		84.72	0.000054	0.88	697.91	188.30	0.12
Reach-1	4140	147.00	78 38	84.61		84.62	0.000046	0.79	680.93	187.79	0 11
Reach-1	4140	124 00	78 38	84.46		84.48	0.000036	0.70	654.04	186.99	0 10
Reach-1	4140	106 00	78.38	85.45		85 46	0.000013	0.47	841.16	191.08	0.06
Reach-1	4140	88 10	78.38	84.00		84 01	0.000027	0 56	568.57	184.41	0.08
Reach-1	4140	91.80	78 38	84.34		84.35	0.000022	0.53	631.47	186 31	0 07
Reach-1	4140	20 80	78.38	80.16		80.23	0.000628	1.12	18.61	14.75	0.32
Reach-1	4140	492 00	78.38	85.93		86.02	0.000210	1.97	932.58	192.23	0.24
Reach-1	4195	12 00	79 33	80.02	80.02	80.24	0.008681	2.09	5.75	13.19	1.01
Reach-1	4195	166 00	79.33	84 70		84.72	0.000078	0.96	677.58	192.31	0.14
Reach-1	4195	147.00	79.33	84 61		84.63	0.000066	0.87	660.18	191.80	0.13
Reach-1	4195	124.00	79.33	84.46		84 48	0.000053	0.76	632.64	191.00	0 11
Reach-1	4195	106.00	79.33	85.45		85.46	0 000018	0.51	823.71	195.80	0.07
Reach-1	4195	88.10	79 33	84.00		84.01	0.000041	0.63	545.24	188.41	0.10
Reach-1	4195	91.80	79.33	84.34		84.35	0.000032	0.59	609.48	190.32	0.09
Reach-1	4195	20.80	79.33	80 22	80.22	80.53	0.007648	2 46	8.45	13.59	1.00
Reach-1	4195	492 00	79.33	85.94		86.04	0.000280	2.11	919.25	197.75	0.27
Reach-1	4250	12.00	79.35	80 37		80.47	0.002240	1.40	8.56	12.91	0.55
Reach-1	4250	166.00	79.35	84.69		84.73	0.000117	1.18	549.49	167.14	0.17
Reach-1	4250	147 00	79.35	84.60		84.63	0 000099	1.08	534.49	166.89	0.16
Reach-1	4250	124 00	79 35	84 46		84.48	0.000080	0.95	510.65	166 49	0.14
Reach-1	4250	106 00	79.35	85 45		85.46	0.000026	0.62	676.81	169.89	0.08
Reach-1	4250	88 10	79 35	84 00		84.02	0.000063	0.79	434.39	165.20	0.12
Reach-1	4250	91 80	79 35	84.34		84.35	0.000049	0.73	490.66	166.15	0.11
Reach-1	4250	20 80	79.35	80 61		80.77	0.002545	1.78	11.69	13.43	0.61
Reach-1	4250	492.00	79 35	85 91		86.07	0.000413	2.58	755.90	171.83	0.33
Reach-1	4302	12 00	79.58	80 49		80.59	0.002438	1.42	8.47	13.49	0.57
Reach-1	4302	166 00	79 58	84.70		84.74	0.000130	1.20	464.98	144.86	0.18
Reach-1	4302	147 00	79 58	84 61		84.64	0.000110	1 09	451.96	144.37	0.16
Reach-1	4302	124 00	79 58	84 46		84.49	0.000089	0.96	431.32	143.60	0.15
Reach-1	4302	106 00	79 58	85 45		85.46	0.000029	0.63	575.55	148.21	0.09
Reach-1	4302	88 10	79.58	84 00		84.02	0.000071	0.79	365.85	141.11	0.13
Reach-1	4302	91 80	79 58	84 34		84.36	0.000055	0.74	414.00	142.95	0.11
Reach-1	4302	20 80	79 58	80 75		80 90	0.002469	1.73	12.02	14.13	0.60
Reach-1	4302	492 00	79 58	85 92		86.10	0.000454	2.62	645.20	149.99	0.35
Reach-1	4350	12 00	79 74	80 59	80.59	80.82	0.007967	2.12	5.67	11.94	0.98
Reach-1	4350	166.00	79 74	84 70		84 75	0.000191	1 42	415.30	136.22	0.21
Reach-1	4350	147 00	79 74	84 61		84.65	0.000163	1.30	403.05	135.85	0.20
Reach-1	4350	124 00	79 74	84 46		84 50	0.000133	1.15	383.62	135 24	0.18
Reach-1	4350	106 00	79 74	85 45		85 46	0.000041	0.73	519 17	139.21	0 10
Reach-1	4350	88 10	79 74	84 00		84 03	0.000109	0 96	321.84	133.31	0.16
Reach-1	4350	91 80	79 74	84 34		84 36	0.000082	0 88	367.30	134.73	0.14
Reach-1	4350	20 80	79 74	80 82	80.80	81.13	0.006836	2.47	8.41	12.29	0 95
Reach-1	4350	492 00	79 74	85.92		86.14	0.000632	3 04	584.70	140.99	0.41
Reach-1	4402	12 00	79 63	80 89		80 94	0.000882	1.01	11.84	14.63	0.36
Reach-1	4402	166 00	79 63	84 72		84 76	0.000121	1.15	465 39	160.64	0.18
Reach-1	4402	147 00	79 63	84 62		84 66	0.000104	1.04	450.38	160.02	0.16
Reach-1	4402	124 00	79 63	84 48		84 50	0.000085	0 93	426.92	159.05	0.15
Reach-1	4402	106 00	79 63	85 45		85 46	0.000026	0 59	585.23	163 87	0.08
Reach-1	4402	88 10	79 63	84 01		84 03	0.000071	0.78	353.91	155.99	0.13
Reach-1	4402	91 80	79 63	84 35		84 37	0.000053	0.72	406.81	158 21	0.11
Reach-1	4402	20 80	79 63	81 18		81 27	0.001045	1 27	16.41	16 41	0.40
Reach-1	4402	492 00	79 63	86 01		86 17	0.000374	2 40	676.61	165.53	0.32
Reach-1	4448	12 00	80 11	81 01	81 01	81 23	0 008558	2 09	5.73	12 92	1.00
Reach-1	4448	166 00	80 11	84 73		84 76	0.000108	0 99	532 10	186.80	0 16
Reach-1	4448	147 00	80 11	84 64		84 66	0.000094	0 91	514.14	186 18	0.15
Reach-1	4448	124 00	80 11	84 49		84 51	0 000078	0 80	486 31	185 22	0 14
Reach-1	4448	106 00	80 11	85 46		85 47	0 000023	0 51	668.72	189 69	0 08
Reach-1	4448	88 10	80 11	84 02		84 04	0 000068	0 68	400.65	182.24	0 12

HEC RAS Plan: jadv River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	4448	91 80	80 11	84 36		84 37	0 000049	0.62	462.08	184.39	0.11
Reach-1	4448	20 80	80.11	81.24	81.24	81.47	0.008330	2.16	9.65	20.51	1.00
Reach-1	4448	492 00	80.11	86.07		86.19	0.000303	2.03	786.00	191.29	0.29
Reach-1	4482	12 00	80.74	81.38	81.38	81.66	0.007997	2.32	5.18	9.62	1.01
Reach-1	4482	166 00	80.74	84.35	83.73	84.94	0.002365	3.45	59.96	81.30	0.68
Reach-1	4482	147 00	80.74	84.33	83.54	84.81	0.001925	3.09	58.14	81.19	0.61
Reach-1	4482	124 00	80.74	84.25	83.28	84 62	0.001574	2.73	51.23	80.78	0.55
Reach-1	4482	106 00	80.74	85.43		85.48	0.000186	1.22	149.74	86.02	0.20
Reach-1	4482	88 10	80.74	83.85		84.12	0.001320	2.32	37.98	17.00	0.50
Reach-1	4482	91 80	80.74	84.22		84.43	0.000898	2.05	49.21	80.66	0 41
Reach-1	4482	20 80	80.74	81.63	81.63	82.01	0.007305	2.71	7.67	10.36	1.01
Reach-1	4482	492 00	80.74	85.66	85 66	86.63	0.002966	5.05	170.23	86.92	0.81
Reach-1	4498	12 00	80.75	81.64		81.72	0.001645	1.31	9.14	11.00	0.46
Reach-1	4498	166 00	80.75	84.28	83.83	85.04	0.003908	3.88	48.65	68.65	0.77
Reach-1	4498	147 00	80.75	84.29	83.63	84.88	0.003037	3.42	49.04	68.68	0.68
Reach-1	4498	124 00	80.75	84.22	83.14	84.68	0.002400	2.99	44.47	68.32	0.60
Reach-1	4498	106.00	80.75	85.42		85.49	0.000276	1.31	130.13	74.27	0.22
Reach-1	4498	88 10	80.75	83.84		84.16	0.001939	2.51	35.17	15.44	0.53
Reach-1	4498	91 80	80.75	84.21		84.46	0.001340	2.23	43.64	68.25	0.45
Reach-1	4498	20 80	80.75	81.94		82.08	0.001860	1.67	12.49	11.00	0.50
Reach-1	4498	492 00	80.75	85.79	85.79	86.78	0.003745	5.16	157.56	75.81	0.81
Reach-1	4548	12 00	80.93	81.66	81.48	81.79	0.000835	1.60	7.49	11.00	0.62
Reach-1	4548	166 00	80.93	84.29	84.01	85.19	0.001343	4.20	39.52	16.27	0.86
Reach-1	4548	147 00	80.93	84.29	83.80	85.00	0.001052	3.72	39.54	16.27	0.76
Reach-1	4548	124 00	80.93	84.24	83.32	84.76	0.000797	3.21	38.66	16.11	0.66
Reach-1	4548	106 00	80.93	85.40	83.10	85.51	0.000122	1.62	115.12	73.58	0.28
Reach-1	4548	88 10	80.93	83.86	82.85	84.23	0.000641	2.69	32.74	14.97	0.58
Reach-1	4548	91 80	80.93	84.22	82.90	84.51	0.000447	2.39	38.34	16.05	0.49
Reach-1	4548	20 80	80.93	81.97	81.69	82.15	0.000787	1.92	10.82	11.00	0.62
Reach-1	4548	492 00	80.93	86.18	86.18	87.46	0.001111	5.59	173.82	76.71	0.86
Reach-1	4624.2	12 00	81.12	81.66	81.66	81.91	0.002360	2.21	5.42	11.00	1.01
Reach-1	4624.2	166 00	81.12	84.22	84.19	85.34	0.001822	4.68	35.44	15.50	0.99
Reach-1	4624.2	147 00	81.12	84.25		85.11	0.001378	4.10	35.89	15.58	0.86
Reach-1	4624.2	124 00	81.12	84.21		84.84	0.001029	3.51	35.29	15.47	0.74
Reach-1	4624.2	106 00	81.12	85.35		85.54	0.000192	1.94	63.95	41.31	0.34
Reach-1	4624.2	88 10	81.12	83.84		84.29	0.000837	2.96	29.77	14.35	0.66
Reach-1	4624.2	91 80	81.12	84.21		84.55	0.000568	2.61	35.20	15.45	0.55
Reach-1	4624.2	20 80	81.12	81.95		82.25	0.001672	2.44	8.51	11.00	0.89
Reach-1	4624.2	492 00	81.12	86.92	86.92	88.26	0.000900	5.45	166.94	87.58	0.79
Reach-1	4624.35	Bridge									
Reach-1	4624.5	12 00	81.27	81.87	81.81	82.07	0.001686	1.99	6.02	11.00	0.86
Reach-1	4624.5	166 00	81.27	84.71	84.34	85.55	0.001212	4.06	40.93	18.47	0.82
Reach-1	4624.5	147 00	81.27	84.31	84.14	85.24	0.001542	4.26	34.48	15.30	0.91
Reach-1	4624.5	124 00	81.27	84.19	83.65	84.92	0.001277	3.80	32.67	14.94	0.82
Reach-1	4624.5	106 00	81.27	85.35	83.43	85.56	0.000226	2.04	58.74	37.59	0.37
Reach-1	4624.5	88 10	81.27	83.83	83.19	84.35	0.000826	3.19	27.60	11.00	0.64
Reach-1	4624.5	91 80	81.27	84.20	83.24	84.60	0.000692	2.80	32.80	14.97	0.60
Reach-1	4624.5	20 80	81.27	82.11	82.03	82.40	0.001588	2.40	8.66	11.00	0.86
Reach-1	4624.5	492 00	81.27	87.46	87.05	88.40	0.000605	4.71	203.03	89.88	0.66
Reach-1	4686	12 00	81.42	81.99	81.97	82.22	0.007889	2.15	5.59	11.00	0.96
Reach-1	4686	166 00	81.42	84.75	84.50	85.68	0.005171	4.26	39.32	19.30	0.88
Reach-1	4686	147 00	81.42	84.38	84.30	85.38	0.006351	4.43	33.19	15.05	0.95
Reach-1	4686	124 00	81.42	84.24		85.05	0.005440	3.99	31.07	14.62	0.87
Reach-1	4686	106 00	81.42	85.37		85.58	0.000923	2.08	61.34	51.90	0.38
Reach-1	4686	88 10	81.42	83.86		84.43	0.003577	3.37	26.15	11.00	0.70
Reach-1	4686	91 80	81.42	84.22		84.67	0.003077	2.99	30.73	14.55	0.66
Reach-1	4686	20 80	81.42	82.21	82.19	82.55	0.007471	2.59	8.02	11.00	0.97
Reach-1	4686	492 00	81.42	88.28		88.50	0.000632	2.71	329.20	113.88	0.36
Reach-1	4750	12 00	81.68	82.31	82.31	82 59	0 008006	2.31	5.19	9.67	1.01
Reach-1	4750	166 00	81.68	84.88		85.76	0.004063	4.14	40.06	17.46	0 87
Reach-1	4750	147 00	81 68	84.61		85 49	0 004520	4 16	35.30	16 61	0 91
Reach-1	4750	124 00	81 68	84.30		85.15	0 004865	4.08	30 42	15.70	0 93
Reach-1	4750	106 00	81.68	85.37		85 60	0 000862	2 13	62 30	63 79	0 41
Reach-1	4750	88 10	81 68	83 82	83 76	84 56	0 005263	3 80	23 18	14 23	0 95

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	4750	91 80	81 68	84 24		84 74	0.002917	3.12	29.45	15 51	0.72
Reach-1	4750	20 80	81.68	82.56	82.56	82.94	0.007296	2.71	7.69	10.42	1.01
Reach-1	4750	492.00	81.68	88.12		88.58	0.000936	3.54	317.78	114.58	0.48
Reach-1	4820	12 00	82.00	82.78		82.89	0.002440	1.44	8.36	13.18	0.58
Reach-1	4820	166 00	82.00	85.79		85.91	0.000479	1.93	313.42	183.87	0.33
Reach-1	4820	148 00	82.00	85.52		85.65	0.000555	1.96	264.59	176.22	0.35
Reach-1	4820	126 00	82.00	85.18		85.32	0.000669	2.00	206.83	159.79	0.38
Reach-1	4820	108.00	82.00	85.58		85.65	0.000271	1.39	275.09	177.90	0.25
Reach-1	4820	90 30	82.00	84.57		84.75	0.001020	2.10	117.34	134.56	0.45
Reach-1	4820	94 60	82.00	84.71		84.87	0.000840	1.98	137.44	140.13	0.41
Reach-1	4820	20 20	82.00	83.07		83.21	0.002093	1.64	12.34	14.08	0.56
Reach-1	4820	489.00	82.00	88.55		88.65	0.000268	2.13	1028.88	287.25	0.27
Reach-1	4950	12.00	82.21	83.13		83.23	0.002809	1.41	8.52	15.26	0.60
Reach-1	4950	166.00	82.21	85.88		85.98	0.000465	1.79	403.44	273.55	0.32
Reach-1	4950	148 00	82.21	85.61		85.73	0.000587	1.90	329.91	271.98	0.35
Reach-1	4950	126 00	82.21	85.26		85.42	0.000826	2.07	237.04	259.44	0.41
Reach-1	4950	108 00	82.21	85.62		85.68	0.000306	1.37	333.06	272.05	0.25
Reach-1	4950	90.30	82.21	84.66		84.95	0.001698	2.49	89.63	226.93	0.56
Reach-1	4950	94.60	82.21	84.79		85.03	0.001334	2.31	120.84	234.55	0.50
Reach-1	4950	20.20	82.21	83.37		83.51	0.002491	1.65	12.28	15.69	0.59
Reach-1	4950	489.00	82.21	88.62		88.69	0.000224	1.87	1173.83	289.03	0.24
Reach-1	5070	12 00	82.08	83.44	83.25	83.63	0.003542	1.91	6.30	7.92	0.68
Reach-1	5070	166.00	82.08	85.91		86.05	0.000950	2.09	304.74	232.98	0.43
Reach-1	5070	148.00	82.08	85.66		85.82	0.001291	2.26	245.00	230.66	0.50
Reach-1	5070	126.00	82.08	85.34		85.57	0.002008	2.52	172.59	215.06	0.60
Reach-1	5070	108.00	82.08	85.64		85.74	0.000706	1.66	242.26	230.55	0.37
Reach-1	5070	90 30	82.08	84.89	84.89	85.24	0.003786	2.86	85.41	177.27	0.79
Reach-1	5070	94 60	82.08	84.95	84.91	85.28	0.003386	2.78	96.52	182.21	0.75
Reach-1	5070	20.20	82.08	83.65	83.52	83.98	0.005128	2.52	8.00	8.62	0.84
Reach-1	5070	489 00	82.08	88.62		88.72	0.000331	2.05	950.70	243.31	0.29
Reach-1	5134	12.00	83.06	83.75	83.75	83.98	0.008675	2.14	5.61	12.38	1.01
Reach-1	5134	166 00	83.06	85.87		86.19	0.002079	2.99	192.98	182.18	0.63
Reach-1	5134	148 00	83.06	85.59		86.03	0.003163	3.38	141.06	180.51	0.76
Reach-1	5134	126 00	83.06	85.38	85.38	85.87	0.003784	3.44	106.00	160.91	0.82
Reach-1	5134	108 00	83.06	85.62		85.84	0.001561	2.40	146.72	180.69	0.54
Reach-1	5134	90 30	83.06	85.02		85.59	0.005219	3.48	54.86	121.54	0.93
Reach-1	5134	94 60	83.06	85.16	85.16	85.61	0.003898	3.19	72.09	136.09	0.81
Reach-1	5134	20 20	83.06	84.06		84.29	0.004540	2.12	9.51	12.62	0.78
Reach-1	5134	489 00	83.06	88.60		88.77	0.000583	2.68	709.50	195.78	0.38
Reach-1	5222	12 00	83.25	84.23		84.33	0.002313	1.39	11.41	20.96	0.56
Reach-1	5222	166 00	83.25	86.03		86.41	0.002983	2.99	120.62	113.13	0.74
Reach-1	5222	148 00	83.25	85.95		86.29	0.002903	2.85	110.85	109.18	0.72
Reach-1	5222	126 00	83.25	85.87		86.15	0.002562	2.58	102.10	106.17	0.67
Reach-1	5222	108 00	83.25	85.75		86.01	0.002514	2.43	90.47	102.03	0.66
Reach-1	5222	90 30	83.25	85.68		85.88	0.002167	2.18	82.87	99.23	0.61
Reach-1	5222	94 60	83.25	85.65		85.89	0.002587	2.34	79.99	98.15	0.66
Reach-1	5222	20 20	83.25	84.44		84.58	0.002674	1.74	15.82	22.49	0.62
Reach-1	5222	489 00	83.25	88.59		88.85	0.000751	2.79	537.88	195.73	0.43
Reach-1	5267	12.00	83.78	84.40	84.40	84.58	0.008850	1.88	6.37	17.65	1.00
Reach-1	5267	166 00	83.78	86.01	85.98	86.61	0.003792	3.52	73.30	108.58	0.85
Reach-1	5267	148 00	83.78	85.94	85.73	86.47	0.003483	3.29	66.31	103.54	0.81
Reach-1	5267	126 00	83.78	85.87	85.61	86.30	0.002938	2.94	59.46	102.15	0.74
Reach-1	5267	108 00	83.78	85.78	85.48	86.15	0.002688	2.70	49.99	100.21	0.70
Reach-1	5267	90 30	83.78	85.71	85.33	86.00	0.002180	2.36	44.24	46.49	0.62
Reach-1	5267	94 60	83.78	85.70	85.37	86.01	0.002478	2.50	43.56	46.00	0.66
Reach-1	5267	20 20	83.78	84.56	84.56	84.80	0.008040	2.15	9.40	19.84	1.00
Reach-1	5267	489 00	83.78	88.55	87.32	88.91	0.000924	3.15	459.84	191.55	0.49
Reach-1	5339	12 00	83.61	84.73	84.37	84.79	0.001206	1.09	11.04	15.61	0.41
Reach-1	5339	166 00	83.61	86.54	86.16	86.86	0.002216	2.51	80.67	113.63	0.63
Reach-1	5339	148 00	83.61	86.41	86.07	86.71	0.002387	2.46	68.63	70.75	0.65
Reach-1	5339	126 00	83.61	86.24	85.92	86.53	0.002626	2.37	57.62	63.07	0.67
Reach-1	5339	108 00	83.61	86.10	85.77	86.37	0.002872	2.30	48.85	60.19	0.68
Reach-1	5339	90 30	83.61	85.94	85 59	86.19	0.003100	2.23	40.46	38.98	0.70
Reach-1	5339	94 60	83.61	85.97	85.64	86.23	0.003197	2.28	41.58	39.84	0.71
Reach-1	5339	20 20	83.61	84.94	84.56	85.04	0.001553	1.40	14.39	16.59	0.48

HEC-RAS Plan: jadp River: RIVER 1 Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5339	489.00	83.61	88.67	87.39	88.98	0.000840	2.72	394.20	187.55	0.45
Reach-1	5400	12.00	84.34	84.88	84.88	85.07	0.008694	1.95	6.14	16.11	1.01
Reach-1	5400	166.00	84.34	86.57	86.57	87.36	0.005061	3.94	44.25	57.46	0.97
Reach-1	5400	148.00	84.34	86.40	86.40	87.18	0.005505	3.90	37.94	24.45	1.00
Reach-1	5400	126.00	84.34	86.22	86.22	86.94	0.005740	3.75	33.61	23.81	1.01
Reach-1	5400	108.00	84.34	86.08	86.08	86.73	0.005811	3.57	30.23	23.30	1.00
Reach-1	5400	90.30	84.34	85.99		86.51	0.005084	3.22	28.08	22.97	0.93
Reach-1	5400	94.60	84.34	86.01	85.96	86.56	0.005308	3.31	28.54	23.04	0.95
Reach-1	5400	20.20	84.34	85.05	85.05	85.31	0.007791	2.26	8.93	17.28	1.00
Reach-1	5400	489.00	84.34	88.32		89.26	0.003013	4.63	234.43	150.28	0.82
Reach-1	5460	12.00	85.03	85.55	85.55	85.73	0.008671	1.90	6.33	25.42	1.00
Reach-1	5460	166.00	85.03	87.14	86.95	87.64	0.003790	3.32	81.36	60.50	0.84
Reach-1	5460	148.00	85.03	86.98	86.86	87.48	0.004228	3.31	71.89	59.21	0.88
Reach-1	5460	126.00	85.03	86.74	86.73	87.28	0.005490	3.41	57.96	57.28	0.97
Reach-1	5460	108.00	85.03	86.62	86.62	87.12	0.005737	3.28	50.78	56.25	0.98
Reach-1	5460	90.30	85.03	86.49	86.49	86.95	0.005864	3.10	43.93	55.56	0.98
Reach-1	5460	94.60	85.03	86.53	86.53	86.99	0.005750	3.13	45.87	55.73	0.97
Reach-1	5460	20.20	85.03	85.70	85.70	85.95	0.007966	2.21	9.13	27.93	1.01
Reach-1	5460	489.00	85.03	88.82	87.37	89.44	0.002450	3.97	293.09	143.55	0.74
Reach-1	5483	12.00	84.89	85.70	85.52	85.85	0.003135	1.68	7.12	18.37	0.65
Reach-1	5483	166.00	84.89	87.80	87.80	88.84	0.005361	4.51	36.79	129.80	1.00
Reach-1	5483	148.00	84.89	87.62	87.62	88.61	0.005469	4.40	33.62	127.92	1.00
Reach-1	5483	126.00	84.89	87.39	87.39	88.30	0.005597	4.24	29.69	113.23	1.00
Reach-1	5483	108.00	84.89	87.18	87.18	88.03	0.005686	4.08	26.44	104.28	1.00
Reach-1	5483	90.30	84.89	86.96	86.96	87.74	0.005815	3.91	23.09	95.79	1.00
Reach-1	5483	94.60	84.89	87.02	87.02	87.81	0.005779	3.95	23.92	97.05	1.00
Reach-1	5483	20.20	84.89	85.82	85.75	86.11	0.005435	2.41	8.39	19.22	0.88
Reach-1	5483	489.00	84.89	88.79	88.60	89.56	0.004722	5.07	305.56	171.74	0.98
Reach-1	5550	12.00	85.38	86.08	86.08	86.30	0.008135	2.05	5.86	13.59	1.00
Reach-1	5550	166.00	85.38	88.90	88.03	89.03	0.000688	1.85	238.14	163.89	0.38
Reach-1	5550	148.00	85.38	88.67	87.82	88.81	0.000821	1.89	200.04	161.85	0.41
Reach-1	5550	126.00	85.38	88.25	87.59	88.57	0.001891	2.52	63.70	138.65	0.60
Reach-1	5550	108.00	85.38	87.97	87.43	88.31	0.002366	2.60	41.54	110.58	0.66
Reach-1	5550	90.30	85.38	87.68	87.25	88.03	0.002498	2.62	34.41	81.61	0.67
Reach-1	5550	94.60	85.38	87.75	87.30	88.10	0.002477	2.62	36.09	88.88	0.67
Reach-1	5550	20.20	85.38	86.26	86.26	86.56	0.007662	2.40	8.42	17.11	1.01
Reach-1	5550	489.00	85.38	89.10	89.10	90.00	0.004345	4.91	271.42	165.66	0.97
Reach-1	5552	12.00	85.16	86.24	85.79	86.32	0.001126	1.19	10.07	13.27	0.41
Reach-1	5552	166.00	85.16	88.90	88.06	89.03	0.000816	2.02	225.40	163.87	0.40
Reach-1	5552	148.00	85.16	88.31	87.88	88.96	0.003118	3.58	41.34	136.76	0.77
Reach-1	5552	126.00	85.16	88.05	87.65	88.66	0.003162	3.44	36.60	109.86	0.77
Reach-1	5552	108.00	85.16	87.83	87.45	88.38	0.003175	3.30	32.69	89.44	0.76
Reach-1	5552	90.30	85.16	87.57	87.23	88.08	0.003303	3.19	28.34	66.22	0.77
Reach-1	5552	94.60	85.16	87.63	87.28	88.16	0.003266	3.22	29.42	72.11	0.77
Reach-1	5552	20.20	85.16	86.44	86.02	86.58	0.001712	1.62	12.46	20.82	0.51
Reach-1	5552	489.00	85.16	89.61	89.23	90.06	0.002179	3.89	344.93	170.11	0.68
Reach-1	5574	12.00	85.25	86.26	85.89	86.35	0.001490	1.31	9.15	11.21	0.46
Reach-1	5574	166.00	85.25	88.49	88.16	89.26	0.003535	3.87	42.95	74.61	0.82
Reach-1	5574	148.00	85.25	88.36	87.98	89.04	0.003310	3.66	40.46	71.87	0.79
Reach-1	5574	126.00	85.25	88.10	87.75	88.74	0.003365	3.52	35.79	66.52	0.79
Reach-1	5574	108.00	85.25	87.88	87.54	88.46	0.003390	3.38	31.93	62.27	0.79
Reach-1	5574	90.30	85.25	87.62	87.33	88.17	0.003525	3.26	27.69	57.75	0.79
Reach-1	5574	94.60	85.25	87.69	87.38	88.24	0.003487	3.29	28.74	58.89	0.79
Reach-1	5574	20.20	85.25	86.47	86.12	86.63	0.002107	1.74	11.60	11.95	0.56
Reach-1	5574	489.00	85.25	89.60	89.18	90.13	0.002525	4.09	208.08	117.78	0.73
Reach-1	5586	12.00	85.30	86.31	85.81	86.36	0.000191	0.95	12.62	14.30	0.32
Reach-1	5586	166.00	85.30	88.87	87.81	89.30	0.000412	2.90	57.27	19.60	0.54
Reach-1	5586	148.00	85.30	88.70	87.64	89.08	0.000391	2.74	53.93	19.42	0.53
Reach-1	5586	126.00	85.30	88.44	87.43	88.78	0.000379	2.58	48.84	19.14	0.52
Reach-1	5586	108.00	85.30	88.20	87.24	88.50	0.000370	2.43	44.36	18.89	0.51
Reach-1	5586	90.30	85.30	87.94	87.04	88.20	0.000370	2.29	39.38	18.60	0.50
Reach-1	5586	94.60	85.30	88.00	87.09	88.28	0.000369	2.33	40.64	18.68	0.50
Reach-1	5586	20.20	85.30	86.56	85.99	86.64	0.000249	1.24	16.30	4.03	0.39
Reach-1	5586	489.00	85.30	90.12	90.12	91.83	0.001125	5.85	113.23	24.43	0.91

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5598	12 00	85 35	86.32	85 81	86.36	0 000163	0.86	14.02	15 60	0 29
Reach-1	5598	166 00	85.35	88.83	87 68	89.33	0 000519	3.13	53.08	15.60	0.54
Reach-1	5598	148 00	85.35	88.67	87.52	89.10	0.000474	2.92	50.60	15.60	0.52
Reach-1	5598	126.00	85.35	88.42	87.30	88.79	0.000435	2.70	46.71	15.60	0 50
Reach-1	5598	108.00	85.35	88.19	87.12	88.51	0.000404	2.50	43.19	15.60	0.48
Reach-1	5598	90.30	85.35	87.94	86.93	88.21	0.000377	2.30	39.20	15.60	0.46
Reach-1	5598	94.60	85.35	88.00	86.98	88.28	0.000383	2.35	40.21	15.60	0.47
Reach-1	5598	20.20	85.35	86.58	85.98	86.65	0.000207	1.12	18.04	15.60	0.33
Reach-1	5598	489.00	85.35	90.30	90.30	92.32	0.001388	6.34	110.14	71.89	0.92
Reach-1	5632.2	12.00	85.48	86.25		86.40	0.001473	1.72	7.00	15.06	0.80
Reach-1	5632.2	166.00	85.48	88.65		89.40	0.000929	3.84	43.21	15.06	0.72
Reach-1	5632.2	148.00	85.48	88.51		89.17	0.000855	3.60	41.13	15.06	0.70
Reach-1	5632.2	126.00	85.48	88.28		88.85	0.000810	3.35	37.61	15.06	0.68
Reach-1	5632.2	108.00	85.48	88.06		88.57	0.000778	3.14	34.40	15.06	0.66
Reach-1	5632.2	90.30	85.48	87.82		88.26	0.000770	2.94	30.68	15.06	0.66
Reach-1	5632.2	94.60	85.48	87.88		88.34	0.000770	2.99	31.63	15.06	0.66
Reach-1	5632.2	20.20	85.48	86.50		86.68	0.001000	1.86	10.88	15.06	0.70
Reach-1	5632.2	489.00	85.48	90.59	90.59	92.87	0.001541	6.72	82.10	27.62	0.98
Reach-1	5632.3	12.00	85.75	86.23	86.23	86.43	0.002777	2.00	6.01	15.00	1.01
Reach-1	5632.3	166.00	85.75	88.62		89.42	0.001821	3.95	41.97	15.00	0.75
Reach-1	5632.3	148.00	85.75	88.49		89.19	0.001647	3.70	39.96	15.00	0.72
Reach-1	5632.3	126.00	85.75	88.26		88.87	0.001522	3.45	36.48	15.00	0.71
Reach-1	5632.3	108.00	85.75	88.05		88.58	0.001429	3.24	33.30	15.00	0.69
Reach-1	5632.3	90.30	85.75	87.80		88.27	0.001377	3.05	29.60	15.00	0.69
Reach-1	5632.3	94.60	85.75	87.86		88.35	0.001387	3.10	30.54	15.00	0.69
Reach-1	5632.3	20.20	85.75	86.48		86.70	0.001720	2.06	9.80	15.00	0.81
Reach-1	5632.3	489.00	85.75	91.17	91.17	92.72	0.001856	5.70	116.86	62.11	0.79
Reach-1	5632.35	Bridge									
Reach-1	5632.4	12.00	86.01	86.68	86.48	86.77	0.000799	1.34	8.96	15.00	0.55
Reach-1	5632.4	166.00	86.01	88.68	88.40	89.61	0.002221	4.26	38.93	15.00	0.84
Reach-1	5632.4	148.00	86.01	88.54	88.23	89.36	0.002054	4.02	36.78	15.00	0.82
Reach-1	5632.4	126.00	86.01	88.30	88.01	89.03	0.001964	3.80	33.18	15.00	0.81
Reach-1	5632.4	108.00	86.01	88.08	87.82	88.74	0.001915	3.61	29.91	15.00	0.82
Reach-1	5632.4	90.30	86.01	87.83	87.63	88.43	0.001942	3.45	26.14	15.00	0.84
Reach-1	5632.4	94.60	86.01	87.89	87.68	88.51	0.001928	3.49	27.10	15.00	0.83
Reach-1	5632.4	20.20	86.01	86.72	86.65	86.95	0.001889	2.13	9.51	15.00	0.85
Reach-1	5632.4	489.00	86.01	93.89	91.43	94.20	0.000295	2.93	343.09	111.40	0.33
Reach-1	5632.5	12.00	86.01	86.68	86.48	86.77	0.000796	1.34	8.97	15.00	0.55
Reach-1	5632.5	166.00	86.01	88.68	88.40	89.61	0.002216	4.26	38.97	15.00	0.84
Reach-1	5632.5	148.00	86.01	88.54	88.23	89.36	0.002050	4.02	36.81	15.00	0.82
Reach-1	5632.5	126.00	86.01	88.30	88.01	89.03	0.001960	3.79	33.21	15.00	0.81
Reach-1	5632.5	108.00	86.01	88.08	87.82	88.74	0.001910	3.61	29.94	15.00	0.82
Reach-1	5632.5	90.30	86.01	87.83	87.62	88.43	0.001936	3.45	26.17	15.00	0.83
Reach-1	5632.5	94.60	86.01	87.89	87.67	88.51	0.001922	3.49	27.13	15.00	0.83
Reach-1	5632.5	20.20	86.01	86.72	86.65	86.95	0.001871	2.12	9.53	15.00	0.85
Reach-1	5632.5	489.00	86.01	93.40	90.84	94.41	0.000741	4.44	110.02	105.39	0.52
Reach-1	5677	12.00	86.06	86.66		86.82	0.005061	1.77	6.76	13.48	0.80
Reach-1	5677	166.00	86.06	89.03		89.67	0.002727	3.54	46.95	18.36	0.71
Reach-1	5677	148.00	86.06	88.81		89.41	0.002857	3.45	42.85	18.36	0.72
Reach-1	5677	126.00	86.06	88.48		89.08	0.003269	3.42	36.90	18.36	0.77
Reach-1	5677	108.00	86.06	88.16		88.78	0.004089	3.48	31.05	18.36	0.85
Reach-1	5677	90.30	86.06	87.83	87.79	88.49	0.005492	3.62	24.93	17.58	0.97
Reach-1	5677	94.60	86.06	87.90	87.84	88.56	0.005141	3.59	26.33	17.86	0.94
Reach-1	5677	20.20	86.06	86.77	86.77	87.07	0.007612	2.44	8.28	13.87	1.01
Reach-1	5677	489.00	86.06	94.06		94.48	0.000530	3.05	213.33	50.87	0.35
Reach-1	5690	12.00	86.11	86.74	86.74	87.02	0.007974	2.32	5.18	9.56	1.00
Reach-1	5690	165.00	86.11	89.10	89.10	90.20	0.005483	4.64	35.57	16.23	1.00
Reach-1	5690	148.00	86.11	88.92	88.92	89.96	0.005556	4.52	32.73	15.72	1.00
Reach-1	5690	125.00	86.11	88.66	88.66	89.62	0.005672	4.34	28.78	15.00	1.00
Reach-1	5690	108.00	86.11	88.46	88.46	89.35	0.005781	4.19	25.76	14.42	1.00
Reach-1	5690	90.60	86.11	88.23	88.23	89.05	0.005897	4.01	22.58	13.78	1.00
Reach-1	5690	93.00	86.11	88.27	88.27	89.10	0.005881	4.04	23.03	13.87	1.00
Reach-1	5690	20.40	86.11	86.98	86.98	87.35	0.007346	2.70	7.54	10.24	1.01
Reach-1	5690	484.00	86.11	94.42		94.51	0.000122	1.51	362.17	136.61	0.18

HEC-RAS Plan: jadz River: RIVER 1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5716	12.00	86.22	87.01		87.16	0.003474	1.74	6.89	10.49	0.69
Reach-1	5716	122.00	86.22	90.09		90.34	0.000913	2.18	56.07	23.77	0.43
Reach-1	5716	109.00	86.22	89.87		90.10	0.000936	2.13	51.29	20.51	0.43
Reach-1	5716	91.50	86.22	89.55		89.76	0.000955	2.04	44.80	19.37	0.43
Reach-1	5716	78.60	86.22	89.29		89.48	0.000971	1.97	39.88	18.46	0.43
Reach-1	5716	65.50	86.22	89.00		89.18	0.000991	1.89	34.68	17.45	0.43
Reach-1	5716	75.80	86.22	88.98		89.23	0.001362	2.21	34.36	17.39	0.50
Reach-1	5716	16.60	86.22	87.35		87.47	0.001817	1.56	10.67	11.68	0.52
Reach-1	5716	362.00	86.22	94.47		94.52	0.000062	1.09	384.41	151.31	0.13
Reach-1	5780	12.00	86.62	87.30	87.30	87.56	0.008025	2.27	5.28	10.20	1.01
Reach-1	5780	122.00	86.62	90.23		90.37	0.000561	2.08	204.05	125.40	0.36
Reach-1	5780	109.00	86.62	89.97		90.13	0.000654	2.14	172.44	124.25	0.39
Reach-1	5780	91.50	86.62	89.59		89.79	0.000883	2.27	125.08	120.77	0.44
Reach-1	5780	78.60	86.62	89.28		89.53	0.001173	2.42	88.43	117.35	0.49
Reach-1	5780	65.50	86.62	88.92		89.26	0.001720	2.64	47.93	100.22	0.58
Reach-1	5780	75.80	86.62	88.85		89.35	0.002676	3.21	41.01	86.51	0.72
Reach-1	5780	16.60	86.62	87.43	87.43	87.74	0.007544	2.49	6.68	10.69	1.00
Reach-1	5780	362.00	86.62	94.48		94.52	0.000098	1.50	1030.72	245.25	0.17
Reach-1	5880	12.00	87.53	88.17	88.17	88.40	0.008212	2.16	5.56	11.87	1.01
Reach-1	5880	122.00	87.53	90.17		90.53	0.001806	2.93	111.99	104.44	0.61
Reach-1	5880	109.00	87.53	89.89		90.33	0.002490	3.16	83.57	98.64	0.71
Reach-1	5880	91.50	87.53	89.56	89.56	90.11	0.003651	3.40	53.03	86.78	0.83
Reach-1	5880	78.60	87.53	89.39	89.39	89.94	0.004158	3.38	38.64	73.18	0.87
Reach-1	5880	65.50	87.53	89.20	89.20	89.74	0.004707	3.30	26.67	54.56	0.91
Reach-1	5880	75.80	87.53	89.35	89.35	89.90	0.004242	3.36	36.03	69.54	0.88
Reach-1	5880	16.60	87.53	88.28	88.28	88.57	0.007743	2.38	6.98	12.41	1.01
Reach-1	5880	362.00	87.53	94.45		94.56	0.000210	2.01	646.32	135.73	0.25
Reach-1	5980	12.00	88.25	88.87		89.02	0.004680	1.73	6.95	13.54	0.77
Reach-1	5980	122.00	88.25	90.38	90.38	91.00	0.003675	3.71	67.98	81.20	0.84
Reach-1	5980	109.00	88.25	90.27	90.27	90.86	0.003705	3.59	59.36	78.28	0.84
Reach-1	5980	91.50	88.25	89.92	89.92	90.67	0.005897	3.93	34.94	52.21	1.02
Reach-1	5980	78.60	88.25	89.92	89.92	90.48	0.004318	3.37	35.10	52.26	0.88
Reach-1	5980	65.50	88.25	89.76	89.76	90.28	0.004665	3.24	26.61	49.62	0.89
Reach-1	5980	75.80	88.25	89.90	89.90	90.44	0.004291	3.32	33.74	51.85	0.87
Reach-1	5980	16.60	88.25	88.98		89.18	0.004710	1.95	8.52	13.85	0.79
Reach-1	5980	362.00	88.25	94.45		94.59	0.000302	2.24	527.25	133.57	0.29
Reach-1	6080	12.00	88.44	89.28		89.42	0.003435	1.64	7.34	12.15	0.67
Reach-1	6080	122.00	88.44	90.81	90.81	91.46	0.004287	3.87	68.35	68.84	0.86
Reach-1	6080	109.00	88.44	90.60		91.33	0.005277	4.01	54.43	66.60	0.94
Reach-1	6080	91.50	88.44	90.66	90.55	91.12	0.003273	3.22	58.39	67.18	0.74
Reach-1	6080	78.60	88.44	90.39	90.39	90.94	0.004394	3.42	40.74	62.50	0.84
Reach-1	6080	65.50	88.44	90.23	90.23	90.75	0.004529	3.26	30.98	57.62	0.85
Reach-1	6080	75.80	88.44	90.36	90.36	90.90	0.004412	3.38	38.72	61.52	0.85
Reach-1	6080	16.60	88.44	89.41		89.59	0.003607	1.87	8.87	12.29	0.70
Reach-1	6080	362.00	88.44	94.41		94.66	0.000620	2.88	416.38	134.27	0.39
Reach-1	6089.2	12.00	87.40	89.45	88.55	89.51	0.000586	1.05	11.43	8.57	0.28
Reach-1	6089.2	122.00	87.40	91.32	91.32	92.08	0.003030	4.09	60.61	78.40	0.73
Reach-1	6089.2	109.00	87.40	90.78	90.78	91.90	0.005218	4.75	26.25	29.50	0.92
Reach-1	6089.2	91.50	87.40	90.59	90.42	91.52	0.004731	4.31	22.79	13.68	0.87
Reach-1	6089.2	78.60	87.40	90.54	90.19	91.26	0.003717	3.78	22.20	12.34	0.77
Reach-1	6089.2	65.50	87.40	90.46	90.00	90.99	0.002926	3.27	21.21	10.93	0.68
Reach-1	6089.2	75.80	87.40	90.53	90.15	91.20	0.003529	3.67	22.03	11.90	0.75
Reach-1	6089.2	16.60	87.40	89.61	88.73	89.70	0.000798	1.31	12.82	8.92	0.34
Reach-1	6089.2	362.00	87.40	94.42	92.94	94.72	0.000855	3.40	394.77	141.21	0.43
Reach-1	6089.3	12.00	87.40	89.44	88.54	89.51	0.000804	1.21	9.94	6.28	0.31
Reach-1	6089.3	122.00	87.40	91.84	91.84	92.43	0.004016	3.80	81.42	76.95	0.61
Reach-1	6089.3	109.00	87.40	91.84	91.84	92.31	0.003217	3.40	81.24	76.83	0.55
Reach-1	6089.3	91.50	87.40	90.64	90.64	92.01	0.009436	5.18	17.66	6.47	1.00
Reach-1	6089.3	78.60	87.40	90.38	90.38	91.61	0.009162	4.92	15.96	6.46	1.00
Reach-1	6089.3	65.50	87.40	90.10	90.10	91.19	0.008871	4.63	14.15	6.45	1.00
Reach-1	6089.3	75.80	87.40	90.32	90.32	91.53	0.009082	4.86	15.60	6.46	1.00
Reach-1	6089.3	16.60	87.40	89.59	88.72	89.71	0.001189	1.53	10.88	6.33	0.37
Reach-1	6089.3	362.00	87.40	94.54	93.20	94.73	0.001322	3.09	388.76	143.05	0.38
Reach-1	6089.35	Bridge									

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	6089.4	12.00	87.50	89.44	88.65	89.51	0.000847	1.24	9.94	8.07	0.33
Reach-1	6089.4	122.00	87.50	92.17	91.45	92.50	0.001285	3.06	124.61	83.00	0.48
Reach-1	6089.4	109.00	87.50	92.51	91.29	92.69	0.000694	2.37	154.41	92.28	0.35
Reach-1	6089.4	91.50	87.50	91.88	90.71	92.13	0.001015	2.60	101.93	76.79	0.42
Reach-1	6089.4	78.60	87.50	91.33	90.49	91.70	0.001614	2.96	61.87	68.38	0.52
Reach-1	6089.4	65.50	87.50	90.86	90.24	91.26	0.002037	3.01	36.66	25.08	0.56
Reach-1	6089.4	75.80	87.50	91.21	90.43	91.62	0.001792	3.05	53.87	66.34	0.54
Reach-1	6089.4	16.60	87.50	89.59	88.82	89.71	0.001171	1.55	11.26	10.13	0.39
Reach-1	6089.4	362.00	87.50	94.52	93.28	94.81	0.000968	3.58	394.83	139.25	0.45
Reach-1	6089.5	12.00	87.50	89.44	88.65	89.52	0.000856	1.24	9.97	8.07	0.33
Reach-1	6089.5	122.00	87.50	92.13	91.55	92.52	0.001478	3.25	121.44	81.96	0.51
Reach-1	6089.5	109.00	87.50	92.49	91.39	92.70	0.000773	2.48	152.83	91.72	0.37
Reach-1	6089.5	91.50	87.50	91.85	90.75	92.15	0.001180	2.77	99.46	76.32	0.45
Reach-1	6089.5	78.60	87.50	91.27	90.53	91.73	0.001970	3.21	57.70	67.32	0.56
Reach-1	6089.5	65.50	87.50	90.81	90.24	91.29	0.002383	3.20	35.48	24.87	0.60
Reach-1	6089.5	75.80	87.50	91.14	90.45	91.65	0.002217	3.32	49.24	65.12	0.59
Reach-1	6089.5	16.60	87.50	89.59	88.82	89.71	0.001195	1.56	11.28	10.12	0.39
Reach-1	6089.5	362.00	87.50	94.44	93.35	94.84	0.001261	4.03	384.32	137.86	0.50
Reach-1	6180	12.00	88.98	89.70	89.70	89.93	0.008007	2.15	5.59	11.89	1.00
Reach-1	6180	122.00	88.98	92.41	91.39	92.57	0.000631	1.95	169.38	119.39	0.37
Reach-1	6180	109.00	88.98	92.63	91.27	92.73	0.000371	1.57	196.07	125.38	0.29
Reach-1	6180	91.50	88.98	92.05	90.98	92.19	0.000616	1.76	128.49	111.24	0.36
Reach-1	6180	78.60	88.98	91.62	90.83	91.80	0.001017	1.98	81.68	102.70	0.45
Reach-1	6180	65.50	88.98	91.06	90.66	91.37	0.002340	2.47	32.32	65.13	0.65
Reach-1	6180	75.80	88.98	91.53	90.80	91.73	0.001124	2.03	73.12	101.10	0.47
Reach-1	6180	16.60	88.98	89.82	89.82	90.10	0.007573	2.35	7.05	12.47	1.00
Reach-1	6180	362.00	88.98	94.66	92.71	94.87	0.000494	2.56	481.02	146.61	0.36
Reach-1	6190.2	12.00	88.90	89.95		90.00	0.000588	0.89	13.43	14.59	0.30
Reach-1	6190.2	122.00	88.90	92.40		92.60	0.000666	2.01	102.19	104.31	0.38
Reach-1	6190.2	109.00	88.90	92.62		92.75	0.000398	1.63	126.14	113.08	0.29
Reach-1	6190.2	91.50	88.90	92.06		92.21	0.000603	1.76	69.67	84.79	0.35
Reach-1	6190.2	78.60	88.90	91.66		91.83	0.000803	1.81	44.85	38.64	0.39
Reach-1	6190.2	65.50	88.90	91.25		91.43	0.001037	1.85	35.33	19.13	0.44
Reach-1	6190.2	75.80	88.90	91.59		91.76	0.000832	1.80	42.48	30.65	0.40
Reach-1	6190.2	16.60	88.90	90.11		90.17	0.000690	1.05	15.81	15.15	0.33
Reach-1	6190.2	362.00	88.90	94.64		94.90	0.000529	2.62	431.44	182.28	0.37
Reach-1	6190.3	12.00	88.90	89.94		90.00	0.000229	1.06	11.27	10.84	0.33
Reach-1	6190.3	122.00	88.90	92.10		92.73	0.000766	3.51	35.13	12.97	0.63
Reach-1	6190.3	109.00	88.90	92.42		92.83	0.000443	2.85	39.56	14.57	0.49
Reach-1	6190.3	91.50	88.90	91.88		92.29	0.000545	2.83	32.45	11.90	0.52
Reach-1	6190.3	78.60	88.90	91.50		91.90	0.000616	2.79	28.20	10.89	0.55
Reach-1	6190.3	65.50	88.90	91.11		91.49	0.000691	2.74	23.95	10.88	0.59
Reach-1	6190.3	75.80	88.90	91.44		91.82	0.000616	2.75	27.52	10.89	0.55
Reach-1	6190.3	16.60	88.90	90.10		90.18	0.000286	1.28	12.93	10.84	0.38
Reach-1	6190.3	362.00	88.90	93.90	93.90	96.05	0.001462	6.55	79.10	42.99	0.94
Reach-1	6190.35	Bridge									
Reach-1	6190.4	12.00	88.90	89.97	89.40	90.03	0.000209	1.03	11.61	10.84	0.32
Reach-1	6190.4	122.00	88.90	92.72	91.25	93.16	0.000421	2.94	44.16	16.06	0.48
Reach-1	6190.4	109.00	88.90	92.89	91.07	93.21	0.000290	2.51	47.14	20.18	0.40
Reach-1	6190.4	91.50	88.90	92.17	90.83	92.51	0.000400	2.58	36.08	13.33	0.46
Reach-1	6190.4	78.60	88.90	91.73	90.65	92.06	0.000478	2.56	30.71	11.15	0.49
Reach-1	6190.4	65.50	88.90	91.27	90.45	91.60	0.000561	2.55	25.70	10.88	0.53
Reach-1	6190.4	75.80	88.90	91.66	90.61	91.99	0.000481	2.53	29.98	10.90	0.49
Reach-1	6190.4	16.60	88.90	90.14	89.52	90.22	0.000255	1.24	13.42	10.84	0.35
Reach-1	6190.4	362.00	88.90	97.70	93.90	98.14	0.000163	3.19	386.82	110.82	0.34
Reach-1	6190.5	12.00	88.90	89.99	89.39	90.03	0.000530	0.87	13.80	14.39	0.28
Reach-1	6190.5	122.00	88.90	93.08	91.00	93.19	0.000400	1.52	132.60	98.43	0.29
Reach-1	6190.5	109.00	88.90	93.15	90.86	93.23	0.000292	1.32	139.53	100.99	0.25
Reach-1	6190.5	91.50	88.90	92.40	90.66	92.53	0.000520	1.57	58.13	48.96	0.32
Reach-1	6190.5	78.60	88.90	91.95	90.51	92.09	0.000605	1.63	48.10	38.09	0.34
Reach-1	6190.5	65.50	88.90	91.48	90.33	91.62	0.000777	1.69	38.68	34.36	0.38
Reach-1	6190.5	75.80	88.90	91.87	90.47	92.01	0.000616	1.63	46.57	37.50	0.34
Reach-1	6190.5	16.60	88.90	90.17	89.50	90.22	0.000604	1.01	16.40	14.96	0.31
Reach-1	6190.5	362.00	88.90	98.13	93.00	98.18	0.000065	1.21	870.16	168.02	0.14

HEC-RAS Plan: jadp River: RIVER 1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	6330	12 00	89 64	90 37	90 37	90 61	0 018541	2 17	5 54	11 67	1 00
Reach-1	6330	122 00	89 64	93.13		93.23	0.000991	1.66	174.67	108.75	0.31
Reach-1	6330	109 00	89 64	93.18		93.26	0.000726	1.44	181.01	108.96	0.26
Reach-1	6330	91 50	89 64	92.44		92.59	0.001770	1.87	101.12	103.98	0.39
Reach-1	6330	78 60	89 64	91.95		92.19	0.003512	2.25	55.47	79.44	0.53
Reach-1	6330	65 50	89 64	91.42		91.80	0.008421	2.78	29.49	32.01	0.78
Reach-1	6330	75 80	89 64	91.87		92.12	0.003892	2.29	49.44	69.26	0.55
Reach-1	6330	16 60	89 64	90.50	90.50	90.77	0.018002	2.32	7.14	13.19	1.01
Reach-1	6330	362 00	89 64	98.14		98.19	0.000157	1.27	763.99	125.95	0.14
Reach-1	6400	12 00	89 95	90.99		91.08	0.003303	1.35	8.90	12.31	0.49
Reach-1	6400	122 00	89 95	93.14		93.35	0.002001	2.48	149.36	130.73	0.46
Reach-1	6400	109 00	89 95	93.19		93.35	0.001456	2.14	156.63	132.87	0.40
Reach-1	6400	91 50	89.95	92.47		92 83	0.003941	2.92	73.32	92.79	0 62
Reach-1	6400	78 60	89.95	92.09		92.59	0.006344	3.28	44.09	63.17	0.77
Reach-1	6400	65 50	89.95	91.88		92.36	0.006913	3.17	32.60	48.80	0.78
Reach-1	6400	75.80	89.95	92.04		92.54	0.006514	3.27	41.13	59.35	0.77
Reach-1	6400	16.60	89.95	91.14		91.26	0.003523	1.56	11.10	16.04	0.51
Reach-1	6400	362.00	89.95	98.16		98.20	0.000164	1.38	974.25	221.06	0.16
Reach-1	6500	12.00	90.58	91.38		91.51	0.005572	1.57	7.65	13.38	0.66
Reach-1	6500	122.00	90.58	93.33		93.57	0.002455	2.56	123.90	117.59	0.52
Reach-1	6500	109.00	90.58	93.33		93.52	0.001965	2.29	123.72	117.54	0.46
Reach-1	6500	91.50	90 58	92.87		93.20	0.003559	2.74	72.86	103.34	0.61
Reach-1	6500	78.60	90.58	92.75		93.06	0.003464	2.61	60.67	98.02	0.60
Reach-1	6500	65 50	90.58	92.56		92.88	0.003842	2.58	42.48	89.47	0.63
Reach-1	6500	75 80	90.58	92.71		93.02	0.003556	2.61	56.60	96.17	0.61
Reach-1	6500	16.60	90.58	91.54		91.69	0.005001	1.70	9.80	14.40	0.64
Reach-1	6500	362.00	90.58	98.19		98.21	0.000100	1.04	1235.88	258.03	0.12
Reach-1	6560	12 00	91.10	91.75		91.88	0.006784	1.58	7.58	15.18	0.72
Reach-1	6560	122.00	91.10	93.52		93.70	0.002108	2.24	139.97	124.00	0.48
Reach-1	6560	109 00	91 10	93.47		93.62	0.001834	2.07	134.39	121.50	0.45
Reach-1	6560	91 50	91.10	93.19		93.36	0.002309	2.13	102.11	107.94	0.50
Reach-1	6560	78 60	91 10	93.06		93.22	0.002287	2.03	88.57	101.72	0.49
Reach-1	6560	65 50	91.10	92.90		93.06	0.002351	1.95	73.07	94.89	0.49
Reach-1	6560	75.80	91 10	93.03		93.19	0.002296	2.01	85.31	100.17	0.49
Reach-1	6560	16 60	91 10	91.88		92.03	0.006512	1.74	9.56	16.13	0.72
Reach-1	6560	362.00	91 10	98.20		98.22	0.000109	1.07	1085.52	223.34	0.13
Reach-1	6610	12.00	90.95	92.01		92.07	0.002348	1.09	11.02	17.89	0.44
Reach-1	6610	122 00	90 95	93.59		93.79	0.001951	2.16	105.93	98.69	0.49
Reach-1	6610	109 00	90.95	93.54		93.71	0.001742	2.01	100.55	97.04	0.46
Reach-1	6610	91 50	90 95	93.28		93.47	0.002149	2.03	76.86	89.87	0.50
Reach-1	6610	78 60	90.95	93.16		93.33	0.002162	1.93	65.74	86.33	0.50
Reach-1	6610	65 50	90.95	93.01		93.17	0.002236	1.84	53.15	82.15	0.50
Reach-1	6610	75.80	90.95	93.12		93.30	0.002176	1.91	63.10	85.47	0.50
Reach-1	6610	16.60	90.95	92.15		92.23	0.002502	1.21	13.77	20.14	0.47
Reach-1	6610	362.00	90.95	98.19		98.22	0.000099	1.08	926.08	211.41	0.13
Reach-1	6700	12 00	90 83	92.16		92.19	0.000772	0.71	16.90	18.70	0.24
Reach-1	6700	122 00	90 83	93.70		94.04	0.002892	2.59	61.66	95.87	0.53
Reach-1	6700	109 00	90.83	93.64		93.93	0.002553	2.39	55.87	89.14	0.50
Reach-1	6700	91 50	90.83	93.44		93.69	0.002457	2.22	43.02	27.13	0.48
Reach-1	6700	78 60	90 83	93.32		93.53	0.002182	2.01	40.02	25.04	0.45
Reach-1	6700	65 50	90 83	93.19		93.35	0.001914	1.80	36.75	22.54	0.42
Reach-1	6700	75.80	90 83	93.30		93.49	0.002126	1.97	39.33	24.53	0 44
Reach-1	6700	16 60	90 83	92.32		92.36	0.000871	0.83	19.93	18.90	0.26
Reach-1	6700	362 00	90 83	98.19		98.24	0.000173	1.28	876 98	240.79	0.15
Reach-1	6800	12 00	92 52	93.09	93.09	93.26	0.019924	1.78	6.77	22.05	1.01
Reach-1	6800	122 00	92 52	94.19	94.19	94.70	0.010146	3.43	66.26	90.35	0.92
Reach-1	6800	109 00	92 52	94.09	94.09	94.59	0.010649	3.35	57.84	82.16	0.93
Reach-1	6800	91 50	92 52	93.99	93.99	94.42	0.010164	3.10	49.91	74.14	0.90
Reach-1	6800	78 60	92 52	93.92	93.92	94.30	0.009522	2.89	44.72	73.14	0 86
Reach-1	6800	65 50	92 52	93.82	93.82	94.17	0.009714	2.74	37.11	71.64	0.86
Reach-1	6800	75 80	92 52	93.90	93.90	94.27	0.009628	2.86	42.99	72.80	0.86
Reach-1	6800	16 60	92 52	93.17	93.17	93.37	0 018692	1 99	8.48	22.91	1 01
Reach-1	6800	362 00	92 52	98 21		98 25	0.000240	1.29	846.01	244.41	0 18
Reach-1	6900	12 00	92 77	94 08	93.79	94.15	0 005014	1.15	10.54	25 7	0 54
Reach-1	6900	119 00	92 77	95.13	95.03	95.43	0 006057	2.77	97.88	143 28	0 72

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	6900	107 00	92 77	95.05	94.96	95.35	0.006183	2.70	86.91	140.42	0.72
Reach-1	6900	90 10	92.77	94 91	94.84	95.22	0.006888	2.66	67.78	127.86	0.74
Reach-1	6900	77 70	92.77	94 80	94.75	95.11	0.007465	2.61	54.51	114.84	0.76
Reach-1	6900	65 00	92 77	94.71	94.65	94.99	0.007418	2.46	44.12	103.52	0.75
Reach-1	6900	119 00	92.77	95 03	95.03	95.42	0.008233	3.08	83.59	139.54	0.83
Reach-1	6900	16.60	92.77	94.18	93.99	94.27	0.005151	1.32	13.21	30.16	0.56
Reach-1	6900	356 00	92 77	98 23		98.28	0.000369	1.43	801.86	265.16	0.21
Reach-1	7050	12.00	93.26	94.65		94.75	0.003186	1.39	8.65	10.26	0.48
Reach-1	7050	119.00	93.26	95.92	95.92	96.84	0.010698	4.54	47.07	44.26	1.02
Reach-1	7050	107.00	93.26	95.94	95.94	96.67	0.008383	4.04	47.79	44.51	0.90
Reach-1	7050	90.10	93.26	95.75		96.43	0.008775	3.87	39.54	41.44	0.91
Reach-1	7050	77.70	93.26	95.69		96.25	0.007352	3.47	37.27	40.55	0.83
Reach-1	7050	65.00	93.26	95.59		96.05	0.006499	3.14	33.12	38.88	0.77
Reach-1	7050	119.00	93.26	95.96	95.92	96.83	0.009940	4.43	48.76	44.86	0.99
Reach-1	7050	16.60	93.26	94.80		94.94	0.003781	1.62	10.24	10.88	0.53
Reach-1	7050	356.00	93.26	98.19		98.41	0.001859	3.12	391.83	176.05	0.48
Reach-1	7150	12.00	94.02	95.12		95.26	0.008851	1.68	7.13	14.08	0.75
Reach-1	7150	64.10	94.02	97.06		97.08	0.000318	0.84	163.99	202.22	0.18
Reach-1	7150	56.20	94.02	96.88		96.91	0.000431	0.93	128.37	196.94	0.21
Reach-1	7150	46.30	94.02	96.68		96.72	0.000599	1.02	89.57	190.59	0.24
Reach-1	7150	39.30	94.02	96.50		96.55	0.000773	1.08	55.08	110.57	0.27
Reach-1	7150	32.60	94.02	96.30		96.36	0.000955	1.10	38.22	61.46	0.29
Reach-1	7150	51.18	94.02	97.04		97.05	0.000219	0.69	158.94	201.58	0.15
Reach-1	7150	11.80	94.02	95.25		95.33	0.004192	1.31	9.02	14.81	0.53
Reach-1	7150	231.00	94.02	98.47		98.49	0.000220	0.98	465.74	218.95	0.16
Reach-1	7250	12.00	94.66	95.68		95.77	0.003268	1.31	9.19	11.92	0.48
Reach-1	7250	64.10	94.66	96.98		97.22	0.002879	2.26	35.43	38.63	0.52
Reach-1	7250	56.20	94.66	96.83		97.06	0.003023	2.20	30.14	32.96	0.52
Reach-1	7250	46.30	94.66	96.68		96.88	0.002820	2.01	25.75	27.38	0.50
Reach-1	7250	39.30	94.66	96.54		96.72	0.002808	1.89	22.24	21.92	0.49
Reach-1	7250	32.60	94.66	96.38		96.54	0.002831	1.76	19.13	18.45	0.48
Reach-1	7250	51.18	94.66	96.99		97.14	0.001799	1.80	35.81	39.01	0.41
Reach-1	7250	11.80	94.66	95.64		95.73	0.003763	1.36	8.65	11.72	0.51
Reach-1	7250	231.00	94.66	98.48		98.55	0.000827	1.78	308.74	220.03	0.31
Reach-1	7320	12.00	94.68	96.03	95.98	96.21	0.013492	1.88	6.37	13.46	0.87
Reach-1	7320	64.10	94.68	97.25		97.44	0.003478	1.99	34.95	34.29	0.54
Reach-1	7320	56.20	94.68	97.12		97.31	0.003863	1.96	30.51	31.45	0.56
Reach-1	7320	46.30	94.68	96.95		97.13	0.004326	1.89	25.49	28.17	0.57
Reach-1	7320	39.30	94.68	96.80		96.98	0.005020	1.87	21.52	25.81	0.61
Reach-1	7320	32.60	94.68	96.65		96.82	0.005967	1.84	17.85	23.43	0.64
Reach-1	7320	51.18	94.68	97.15		97.30	0.002927	1.73	31.53	32.13	0.49
Reach-1	7320	11.80	94.68	96.03	95.97	96.20	0.013115	1.86	6.36	13.45	0.86
Reach-1	7320	231.00	94.68	98.46		98.66	0.002239	2.41	165.95	144.84	0.48
Reach-1	7420	12.00	96.26	97.21		97.38	0.010247	1.82	6.80	14.51	0.79
Reach-1	7420	64.10	96.26	98.22	98.22	98.65	0.007272	3.06	35.52	62.51	0.79
Reach-1	7420	56.20	96.26	97.95	97.95	98.51	0.011719	3.41	20.77	23.76	0.97
Reach-1	7420	46.30	96.26	97.81	97.81	98.31	0.011865	3.18	17.70	22.03	0.96
Reach-1	7420	39.30	96.26	97.70	97.70	98.15	0.012461	3.03	15.27	20.55	0.97
Reach-1	7420	32.60	96.26	97.58	97.58	97.99	0.013317	2.88	12.90	19.01	0.98
Reach-1	7420	51.18	96.26	97.89	97.89	98.41	0.011523	3.27	19.39	23.00	0.96
Reach-1	7420	11.80	96.26	97.20		97.37	0.010473	1.83	6.67	14.40	0.80
Reach-1	7420	231.00	96.26	99.33	99.33	100.12	0.008377	4.73	108.24	67.46	0.93
Reach-1	7500	12.00	97.06	98.06	98.00	98.30	0.012354	2.20	5.72	14.75	0.88
Reach-1	7500	64.10	97.06	98.98	98.98	99.43	0.010213	3.38	43.20	58.08	0.91
Reach-1	7500	56.20	97.06	98.95		99.32	0.008678	3.07	41.28	57.39	0.83
Reach-1	7500	46.30	97.06	98.79		99.17	0.009711	3.00	32.66	54.17	0.86
Reach-1	7500	39.30	97.06	98.69		99.05	0.010111	2.89	27.22	52.03	0.87
Reach-1	7500	32.60	97.06	98.59		98.93	0.010304	2.74	22.10	49.94	0.86
Reach-1	7500	51.18	97.06	98.86		99.25	0.009385	3.06	36.51	55.63	0.86
Reach-1	7500	11.80	97.06	98.05	97.99	98.29	0.012129	2.17	5.67	14.58	0.87
Reach-1	7500	231.00	97.06	100.22	100.22	100.81	0.007975	4.55	171.23	151.36	0.89
Reach-1	7600	12.00	98.67	99.33	99.28	99.51	0.011794	1.91	6.62	17.73	0.85
Reach-1	7600	64 10	98.67	100.24	100.24	100.60	0.007931	2.96	51.69	108.36	0.81
Reach-1	7600	56 20	98.67	100.13	100.13	100.51	0.008599	2.92	41.45	90.40	0.83
Reach-1	7600	46 30	98.67	99.98	99.98	100.36	0.009817	2.88	29.39	68.76	0.87

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	7600	39 30	98 67	99 82	99 82	100 23	0 012139	2 94	20 70	42 03	0 91
Reach-1	7600	32 60	98 67	99.73	99.73	100.09	0.011697	2.72	17.34	35.39	0.92
Reach-1	7600	51 18	98 67	100.06	100.06	100.44	0.009005	2.88	35.69	78.86	0.85
Reach-1	7600	11 80	98 67	99.32	99.27	99.51	0.012031	1.91	6.47	17.37	0.86
Reach-1	7600	231 00	98 67	101.08		101.43	0.006635	3.74	202.63	229.83	0.81
Reach-1	7650	12 00	98 92	99.81		99.98	0.007572	1.85	6.49	9.50	0.71
Reach-1	7650	64 10	98 92	100.79	100.79	101.15	0.006885	3.05	60.31	109.10	0.77
Reach-1	7650	56 20	98 92	100.72	100.72	101.06	0.006730	2.92	52.38	102.88	0.75
Reach-1	7650	46 30	98 92	100.60	100.60	100.93	0.006778	2.77	40.83	93.08	0.74
Reach-1	7650	39 30	98 92	100.47	100.47	100.82	0.007526	2.75	29.91	80.98	0.77
Reach-1	7650	32 60	98 92	100.30	100.30	100.68	0.009212	2.80	18.17	54.97	0.84
Reach-1	7650	51 18	98 92	100.66	100 66	101.00	0.006724	2.84	46.72	98.20	0.75
Reach-1	7650	11 80	98 92	99.80		99.97	0.007450	1.83	6.46	9.49	0.70
Reach-1	7650	231 00	98 92	101.61	101.61	101.90	0.005940	3.72	229.26	267.66	0.76
Reach-1	7700	12 00	99 56	100.27		100.46	0.012289	1.94	6.20	12.21	0.87
Reach-1	7700	64 10	99 56	101.20	101.20	101.76	0.010831	3.31	22.80	37.92	0.94
Reach-1	7700	56.20	99 56	101.07	101.07	101.61	0.011893	3.27	18.27	29.82	0.97
Reach-1	7700	46.30	99 56	100.94	100.90	101.41	0.011667	3.04	15.37	15.88	0.94
Reach-1	7700	39.30	99 56	100.88		101.26	0.009939	2.72	14.51	15.27	0.86
Reach-1	7700	32 60	99 56	100.84		101.12	0.007972	2.37	13.78	14.74	0.77
Reach-1	7700	51.18	99.56	100.97	100.97	101.51	0.012885	3.25	15.92	16.27	0.99
Reach-1	7700	11.80	99.56	100.26		100.45	0.012452	1.93	6.10	12.16	0.87
Reach-1	7700	231.00	99.56	102.25	102.25	102.58	0.005587	3.47	240.00	313.65	0.74
Reach-1	7750	12.00	100 59	101.04	101.04	101.20	0.017835	1.74	6.90	21.36	0.98
Reach-1	7750	64.10	100.59	101.97		102.15	0.005122	1.93	36.55	61.17	0.63
Reach-1	7750	56.20	100 59	101.86		102.05	0.005695	1.90	30.88	50.60	0.65
Reach-1	7750	46.30	100 59	101.71		101.89	0.007355	1.91	24.28	34.42	0.72
Reach-1	7750	39 30	100 59	101.56		101.76	0.009568	2.02	19.44	29.95	0.80
Reach-1	7750	32.60	100 59	101.39		101.64	0.013620	2.22	14.72	25.77	0.94
Reach-1	7750	51.18	100 59	101.80		101.98	0.006127	1.88	27.76	43.72	0.66
Reach-1	7750	11 80	100 59	101.04	101.03	101.19	0.017741	1.72	6.84	21.35	0.97
Reach-1	7750	231 00	100 59	102.73	102.73	103.10	0.005828	3.04	181.85	298.95	0.74
Reach-1	7800	12.00	101 13	101.84	101.82	102.02	0.014855	1.85	6.50	16.71	0.95
Reach-1	7800	64 10	101 13	102.59	102.59	102.96	0.009436	2.81	38.94	69.11	0.88
Reach-1	7800	56 20	101 13	102.46	102.46	102.86	0.012050	2.91	29.82	58.70	0.98
Reach-1	7800	46 30	101 13	102.38	102.38	102.72	0.011005	2.65	25.68	54.54	0.92
Reach-1	7800	39 30	101 13	102.30	102.30	102.61	0.011468	2.54	21.31	49.77	0.93
Reach-1	7800	32 60	101 13	102.21	102.21	102.50	0.012317	2.43	16.98	44.56	0.94
Reach-1	7800	51.18	101 13	102.43	102.43	102.79	0.010973	2.74	28.45	57.36	0.93
Reach-1	7800	11.80	101 13	101.84	101.82	102.01	0.014885	1.84	6.42	16.67	0.94
Reach-1	7800	231 00	101 13	103.02	103.02	104.82	0.033722	6.52	69.57	113.25	1.75
Reach-1	7850	12.00	101 67	102.42		102.59	0.009019	1.81	6.63	11.92	0.78
Reach-1	7850	64 10	101 67	103.41	103.41	103.84	0.007993	2.99	35.59	74.31	0.83
Reach-1	7850	56 20	101 67	103.24	103.24	103.73	0.009935	3.11	23.96	56.82	0.91
Reach-1	7850	46 30	101 67	103.05	103.05	103.54	0.011732	3.11	15.54	30.81	0.97
Reach-1	7850	39 30	101 67	102.91	102.91	103.38	0.012894	3.05	12.90	13.71	1.00
Reach-1	7850	32 60	101 67	102.79	102.79	103.21	0.013231	2.89	11.28	13.27	1.00
Reach-1	7850	51.18	101 67	103.17	103.17	103.64	0.010234	3.06	20 06	46.66	0.92
Reach-1	7850	11 80	101 67	102.41		102.58	0.008967	1.80	6.57	11.90	0.77
Reach-1	7850	231 00	101 67	105.06	104.56	105.26	0.002468	2.68	282.83	199.80	0.50
Reach-1	7861.2	12 00	102 09	102.89	102.89	103.25	0.010091	2 65	4.53	9.91	1.01
Reach-1	7861.2	64 10	102 09	104.41	104.41	104.65	0.002425	2.78	96 80	194.60	0.60
Reach-1	7861.2	56 20	102 09	104.35	104.35	104.59	0.002294	2.66	85.93	192.01	0.58
Reach-1	7861.2	46 30	102 09	104.26	104.26	104.50	0.002157	2.51	69 61	188.06	0.56
Reach-1	7861.2	39 30	102 09	103.75	103.75	104.53	0.007621	3.91	10.04	19.07	1.00
Reach-1	7861.2	32 60	102 09	103.57	103.57	104.26	0.007941	3.68	8.86	13.93	1.00
Reach-1	7861.2	51 18	102 09	104.31	104.31	104.54	0 002230	2.59	77 88	190.07	0.57
Reach-1	7861.2	11 80	102 09	102.89	102.89	103.24	0.009991	2.62	4 50	9.89	1.00
Reach-1	7861.2	231 00	102 09	105.05	105.05	105.43	0.004410	4.45	233.00	221.35	0.84
Reach-1	7861.3	12 00	102 09	103.08		103.30	0.006296	2.10	5 72	6.40	0.71
Reach-1	7861.3	64.10	102 09	104.28		104.73	0.007644	3 50	60 65	188 62	0.77
Reach-1	7861.3	56.20	102 09	104.49		104 61	0.002317	2 06	102 33	198.53	0 43
Reach-1	7861.3	46 30	102 09	104 26		104.52	0 004237	2 60	58 15	138 01	0 58
Reach-1	7861.3	39.30	102.09	104.02	103 75	104 58	0.008085	3 34	14 32	160 50	0.79
Reach-1	7861.3	32 60	102 09	103 82	103.56	104 32	0 007722	3 11	10 49	6 40	0.77

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	7861.3	51 18	102 09	104.44		104.56	0 002411	2.07	91.44	195.99	0 44
Reach-1	7861.3	11.80	102.09	103.07		103.29	0.006300	2.08	5.66	6.40	0.71
Reach-1	7861.3	231 00	102 09	105.35		105.47	0.002915	2 85	288.60	228.96	0.51
Reach-1	7861.35	Bndge									
Reach-1	7861.4	12.00	102.16	103.06	102.96	103.34	0.008725	2.33	5.14	6.40	0.83
Reach-1	7861.4	64.10	102.16	104.66	104.66	104.98	0.004415	2.95	57.61	124.65	0.61
Reach-1	7861.4	56.20	102.16	104.57	104.57	104.90	0.004439	2.88	47.16	106.85	0.61
Reach-1	7861.4	46.30	102.16	104.44	104.39	104.76	0.004332	2.74	35.94	72.12	0.59
Reach-1	7861.4	39.30	102.16	104.50	103.82	104.70	0.002641	2.18	40.45	93.66	0.46
Reach-1	7861.4	32.60	102.16	103.80	103.63	104.35	0.009177	3.30	9.88	6.40	0.85
Reach-1	7861.4	51.18	102.16	104.49	104.49	104.83	0.004673	2.89	39.24	74.79	0.62
Reach-1	7861.4	11.80	102.16	103.05	102.95	103.32	0.008769	2.32	5.08	6.40	0.83
Reach-1	7861.4	231.00	102.16	105.42	105.42	105.80	0.006515	4.31	200.83	232.12	0.77
Reach-1	7861.5	12.00	102.16	103.21	102.96	103.41	0.003666	1.96	6.14	11.40	0.64
Reach-1	7861.5	64.10	102.16	104.88	104.52	105.03	0.001240	2.23	101.00	168.19	0.44
Reach-1	7861.5	56.20	102.16	104.81	104.36	104.95	0.001164	2.12	88.69	153.10	0.42
Reach-1	7861.5	46.30	102.16	104.67	104.00	104.81	0.001115	2.00	70.25	127.16	0.41
Reach-1	7861.5	39.30	102.16	104.61	103.82	104.73	0.000942	1.81	62.89	115.19	0.38
Reach-1	7861.5	32.60	102.16	103.99	103.64	104.43	0.003727	2.93	11.12	23.87	0.71
Reach-1	7861.5	51.18	102.16	104.75	104.27	104.89	0.001118	2.04	80.41	142.03	0.41
Reach-1	7861.5	11.80	102.16	103.20	102.95	103.40	0.003667	1.94	6.07	11.25	0.64
Reach-1	7861.5	231.00	102.16	105.53	105.46	105.92	0.003518	4.34	236.33	249.92	0.77
Reach-1	7950	12.00	102.93	103.66	103.66	103.92	0.015600	2.28	5.26	10.09	1.01
Reach-1	7950	64.10	102.93	104.75	104.75	105.29	0.009893	3.30	22.24	26.16	0.92
Reach-1	7950	56.20	102.93	104.73		105.16	0.008044	2.95	21.65	25.62	0.83
Reach-1	7950	46.30	102.93	104.65		104.99	0.006709	2.61	19.63	23.67	0.75
Reach-1	7950	39.30	102.93	104.60		104.87	0.005417	2.31	18.61	22.62	0.67
Reach-1	7950	32.60	102.93	104.42		104.68	0.006164	2.28	14.84	18.23	0.70
Reach-1	7950	51.18	102.93	104.70		105.08	0.007202	2.76	20.87	24.89	0.78
Reach-1	7950	11.80	102.93	103.65	103.65	103.92	0.015649	2.27	5.20	10.06	1.01
Reach-1	7950	231.00	102.93	105.97	105.97	106.35	0.005007	3.56	177.99	232.53	0.73
Reach-1	7962.1	12.00	103.56	104.29	104.29	104.55	0.011539	2.27	5.29	10.25	1.01
Reach-1	7962.1	64.10	103.56	105.31	105.31	105.86	0.006667	3.45	26.11	32.22	0.91
Reach-1	7962.1	56.20	103.56	105.18	105.18	105.72	0.007159	3.37	22.32	28.48	0.93
Reach-1	7962.1	46.30	103.56	105.00	105.00	105.51	0.008162	3.26	17.67	23.06	0.97
Reach-1	7962.1	39.30	103.56	104.93	104.93	105.36	0.007524	2.99	15.96	22.27	0.92
Reach-1	7962.1	32.60	103.56	104.80	104.80	105.20	0.008104	2.86	13.24	21.01	0.93
Reach-1	7962.1	51.18	103.56	105.09	105.09	105.62	0.007657	3.32	19.88	25.77	0.95
Reach-1	7962.1	11.80	103.56	104.28	104.28	104.54	0.011586	2.26	5.22	10.22	1.01
Reach-1	7962.1	231.00	103.56	106.41	106.41	106.77	0.003771	3.77	196.39	216.86	0.75
Reach-1	7962.2	12.00	103.88	104.70	104.64	104.96	0.007818	2.25	5.33	10.21	0.87
Reach-1	7962.2	64.10	103.88	106.25	106.25	106.64	0.002964	3.05	48.06	122.76	0.65
Reach-1	7962.2	56.20	103.88	105.76	105.76	106.64	0.007564	4.14	13.58	17.68	1.00
Reach-1	7962.2	46.30	103.88	105.55	105.55	106.32	0.007922	3.88	11.93	14.70	1.00
Reach-1	7962.2	39.30	103.88	105.39	105.39	106.08	0.008220	3.68	10.69	13.46	1.00
Reach-1	7962.2	32.60	103.88	105.23	105.23	105.84	0.008539	3.45	9.45	12.66	1.00
Reach-1	7962.2	51.18	103.88	105.66	105.66	106.48	0.007679	4.00	12.78	16.24	1.00
Reach-1	7962.2	11.80	103.88	104.70	104.63	104.95	0.007745	2.23	5.29	10.19	0.87
Reach-1	7962.2	231.00	103.88	107.12	107.12	107.47	0.003249	3.98	222.93	247.15	0.72
Reach-1	7962.3	12.00	103.88	104.73		104.97	0.007655	2.17	5.53	7.80	0.82
Reach-1	7962.3	64.10	103.88	105.92	105.92	106.87	0.011372	4.33	14.80	7.80	1.00
Reach-1	7962.3	56.20	103.88	105.91		106.65	0.008900	3.82	14.71	7.80	0.89
Reach-1	7962.3	46.30	103.88	105.69		106.33	0.008620	3.56	13.01	7.80	0.88
Reach-1	7962.3	39.30	103.88	105.52		106.10	0.008420	3.35	11.72	7.80	0.87
Reach-1	7962.3	32.60	103.88	105.36		105.86	0.008236	3.13	10.41	7.80	0.87
Reach-1	7962.3	51.18	103.88	105.80		106.49	0.008778	3.69	13.85	7.80	0.89
Reach-1	7962.3	11.80	103.88	104.73		104.96	0.007589	2.15	5.49	7.80	0.82
Reach-1	7962.3	231.00	103.88	107.25		107.48	0.003484	3.39	236.17	263.57	0.60
Reach-1	7962.35	Bndge									
Reach-1	7962.4	12.00	103.88	104.78	104.64	104.99	0.006217	2.03	5.92	7.80	0.74
Reach-1	7962.4	64.10	103.88	106.94	105.92	106.98	0.000622	1.34	160.88	225.22	0.25
Reach-1	7962.4	56 20	103.88	105.98	105.76	106.67	0.007939	3.68	15.32	13.02	0.84
Reach-1	7962.4	46 30	103.88	105.77	105.55	106.36	0.007501	3.39	13.65	7.80	0.82

HEC-RAS Plan: Lady River: RIVER 1 Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	7962.4	39.30	103.88	105.60	105.39	106.12	0.007297	3.19	12.31	7.80	0.81
Reach-1	7962.4	32.60	103.88	105.42	105.23	105.88	0.007136	2.98	10.92	7.80	0.80
Reach-1	7962.4	51.18	103.88	105.89	105.66	106.52	0.007635	3.52	14.54	7.80	0.82
Reach-1	7962.4	11.80	103.88	104.77	104.63	104.98	0.006189	2.01	5.86	7.80	0.74
Reach-1	7962.4	231.00	103.88	107.37	107.13	107.54	0.002535	2.97	270.38	278.24	0.52
Reach-1	7962.5	12.00	103.88	104.79	104.64	105.00	0.005925	2.00	6.01	7.80	0.73
Reach-1	7962.5	64.10	103.88	106.94	105.92	106.98	0.000621	1.34	161.02	225.28	0.25
Reach-1	7962.5	56.20	103.88	106.00	105.76	106.68	0.007640	3.63	15.47	63.34	0.82
Reach-1	7962.5	46.30	103.88	105.79	105.55	106.36	0.007254	3.35	13.81	7.80	0.80
Reach-1	7962.5	39.30	103.88	105.62	105.39	106.13	0.007060	3.16	12.45	7.80	0.80
Reach-1	7962.5	32.60	103.88	105.44	105.23	105.88	0.006883	2.95	11.06	7.80	0.79
Reach-1	7962.5	51.18	103.88	105.91	105.66	106.52	0.007393	3.48	14.70	7.80	0.81
Reach-1	7962.5	11.80	103.88	104.78	104.63	104.98	0.005898	1.98	5.95	7.80	0.72
Reach-1	7962.5	231.00	103.88	107.38	107.12	107.54	0.002498	2.95	272.10	278.96	0.51
Reach-1	7962.6	12.00	103.94	104.83		105.05	0.006351	2.04	5.88	7.80	0.75
Reach-1	7962.6	64.10	103.94	106.93		107.00	0.000707	1.56	143.50	225.44	0.29
Reach-1	7962.6	56.20	103.94	106.60	105.86	106.75	0.001429	2.04	79.22	164.81	0.41
Reach-1	7962.6	46.30	103.94	105.91		106.42	0.005315	3.18	15.70	11.90	0.75
Reach-1	7962.6	39.30	103.94	105.69		106.18	0.005989	3.10	13.23	10.35	0.78
Reach-1	7962.6	32.60	103.94	105.50		105.94	0.006360	2.93	11.36	9.00	0.79
Reach-1	7962.6	51.18	103.94	106.10	105.74	106.58	0.004538	3.13	21.85	62.20	0.70
Reach-1	7962.6	11.80	103.94	104.83		105.04	0.006333	2.03	5.82	7.80	0.75
Reach-1	7962.6	231.00	103.94	107.36		107.58	0.002718	3.35	248.57	256.35	0.59
Reach-1	8100	12.00	104.87	105.66	105.66	105.83	0.018928	1.81	6.63	19.98	1.00
Reach-1	8100	64.10	104.87	106.92		107.09	0.002637	1.89	43.04	60.41	0.48
Reach-1	8100	56.20	104.87	106.68		106.88	0.003680	2.00	30.84	42.66	0.55
Reach-1	8100	46.30	104.87	106.52		106.70	0.003883	1.88	24.99	30.69	0.56
Reach-1	8100	39.30	104.87	106.33		106.51	0.005196	1.93	20.50	21.65	0.62
Reach-1	8100	32.60	104.87	106.14		106.34	0.007394	1.99	16.42	21.27	0.72
Reach-1	8100	51.18	104.87	106.65		106.83	0.003348	1.87	29.41	40.06	0.53
Reach-1	8100	11.80	104.87	105.66	105.66	105.82	0.018978	1.80	6.56	19.97	1.00
Reach-1	8100	231.00	104.87	107.76	107.76	108.17	0.004579	3.31	183.08	270.55	0.68
Reach-1	8150	12.00	105.55	106.47	106.45	106.71	0.015712	2.14	5.60	10.98	0.96
Reach-1	8150	64.10	105.55	107.39	107.39	107.87	0.012656	3.09	22.43	30.05	0.98
Reach-1	8150	56.20	105.55	107.31	107.31	107.75	0.012912	2.96	20.09	27.94	0.97
Reach-1	8150	46.30	105.55	107.18	107.18	107.59	0.014373	2.83	16.73	24.62	1.00
Reach-1	8150	39.30	105.55	107.10	107.10	107.46	0.014791	2.68	14.80	22.49	1.00
Reach-1	8150	32.60	105.55	107.01	107.01	107.33	0.015660	2.53	12.90	20.18	1.00
Reach-1	8150	51.18	105.55	107.25	107.25	107.67	0.013415	2.88	18.45	26.38	0.98
Reach-1	8150	11.80	105.55	106.47	106.45	106.70	0.015608	2.12	5.55	10.97	0.95
Reach-1	8150	231.00	105.55	108.41	108.41	108.76	0.005950	3.36	205.08	281.75	0.75
Reach-1	8200	12.00	106.40	107.28		107.39	0.011621	1.48	8.10	22.68	0.79
Reach-1	8200	64.10	106.40	108.08		108.31	0.005849	2.13	34.23	44.13	0.67
Reach-1	8200	56.20	106.40	107.99		108.20	0.006214	2.07	30.19	42.56	0.68
Reach-1	8200	46.30	106.40	107.87		108.06	0.006332	1.95	25.49	38.27	0.67
Reach-1	8200	39.30	106.40	107.77		107.95	0.006627	1.88	21.94	34.73	0.68
Reach-1	8200	32.60	106.40	107.69		107.84	0.006813	1.76	18.98	32.07	0.67
Reach-1	8200	51.18	106.40	107.93		108.13	0.006330	2.02	27.69	40.34	0.68
Reach-1	8200	11.80	106.40	107.27		107.38	0.011783	1.48	7.97	22.58	0.80
Reach-1	8200	231.00	106.40	109.07	109.07	109.44	0.005009	3.08	178.28	289.96	0.69
Reach-1	8250	12.00	107.32	108.13	108.13	108.41	0.015337	2.38	5.24	11.75	0.99
Reach-1	8250	64.10	107.32	109.36	109.36	109.73	0.005761	3.09	55.52	98.38	0.73
Reach-1	8250	56.20	107.32	109.26	109.26	109.63	0.006022	3.03	45.74	89.63	0.74
Reach-1	8250	46.30	107.32	108.94	108.94	109.45	0.009943	3.40	23.32	33.29	0.92
Reach-1	8250	39.30	107.32	108.83	108.83	109.30	0.009857	3.21	19.82	30.26	0.90
Reach-1	8250	32.60	107.32	108.69	108.69	109.13	0.010259	3.04	16.05	26.61	0.90
Reach-1	8250	51.18	107.32	109.20	109.20	109.56	0.006003	2.96	40.43	84.51	0.73
Reach-1	8250	11.80	107.32	108.12	108.12	108.40	0.015461	2.37	5.16	11.57	0.99
Reach-1	8250	231.00	107.32	110.20	110.20	110.59	0.006457	4.20	219.99	229.74	0.82
Reach-1	8300	12.00	108.36	109.03	109.03	109.28	0.016887	2.18	5.50	11.55	1.01
Reach-1	8300	64.10	108.36	110.01	110.01	110.58	0.011706	3.35	20.36	26.90	0.97
Reach-1	8300	56.20	108.36	109.89	109.89	110.43	0.012449	3.27	17.55	20.61	0.99
Reach-1	8300	46.30	108.36	109.73	109.73	110.23	0.013178	3.12	14.88	15.72	1.00
Reach-1	8300	39.30	108.36	109.62	109.62	110.07	0.013779	2.99	13.13	14.55	1.01
Reach-1	8300	32.60	108.36	109.50	109.50	109.91	0.014248	2.86	11.41	13.93	1.01

HEC-RAS Plan: jadp River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	8300	51.18	108.36	109.81	109.81	110.33	0.012845	3.20	16.10	16.85	1.00
Reach-1	8300	11.80	108.36	109.03	109.03	109.27	0.016947	2.17	5.43	11.52	1.01
Reach-1	8300	231.00	108.36	111.23	111.23	111.57	0.004683	3.38	246.93	325.53	0.69
Reach-1	8313.1	12.00	108.75	109.58		109.82	0.013342	2.16	5.55	9.74	0.91
Reach-1	8313.1	64.10	108.75	110.67	110.67	111.28	0.009062	3.54	23.72	29.65	0.89
Reach-1	8313.1	56.20	108.75	110.43	110.43	111.11	0.012280	3.70	17.72	17.67	1.01
Reach-1	8313.1	46.30	108.75	110.32	110.32	110.88	0.011323	3.35	15.75	17.10	0.96
Reach-1	8313.1	39.30	108.75	110.20	110.20	110.70	0.011652	3.17	13.72	16.50	0.95
Reach-1	8313.1	32.60	108.75	110.07	110.07	110.53	0.012266	3.00	11.62	15.85	0.96
Reach-1	8313.1	51.18	108.75	110.42	110.42	110.99	0.010666	3.41	17.41	17.58	0.94
Reach-1	8313.1	11.80	108.75	109.57		109.81	0.013253	2.15	5.50	9.71	0.91
Reach-1	8313.1	231.00	108.75	112.06	112.06	112.38	0.003913	3.53	266.26	337.69	0.65
Reach-1	8313.2	12.00	109.14	110.04	110.03	110.42	0.015540	2.73	4.40	8.10	1.00
Reach-1	8313.2	64.10	109.14	111.78	111.78	112.12	0.004020	3.08	58.81	123.67	0.62
Reach-1	8313.2	56.20	109.14	111.40	111.40	112.46	0.011035	4.57	12.30	34.27	1.00
Reach-1	8313.2	46.30	109.14	111.14	111.14	112.08	0.011518	4.28	10.81	28.36	1.00
Reach-1	8313.2	39.30	109.14	110.95	110.95	111.79	0.011955	4.06	9.69	23.70	1.00
Reach-1	8313.2	32.60	109.14	110.76	110.76	111.50	0.012400	3.80	8.57	18.37	1.00
Reach-1	8313.2	51.18	109.14	111.28	111.28	112.27	0.011212	4.42	11.58	31.38	1.00
Reach-1	8313.2	11.80	109.14	110.03	110.03	110.41	0.015472	2.71	4.36	8.08	1.00
Reach-1	8313.2	231.00	109.14	112.59	112.59	112.88	0.004728	4.02	276.64	322.26	0.71
Reach-1	8313.3	12.00	109.14	110.15		110.44	0.011602	2.38	5.05	5.80	0.81
Reach-1	8313.3	64.10	109.14	111.72		112.16	0.009203	3.37	43.80	107.55	0.69
Reach-1	8313.3	56.20	109.14	111.43	111.43	112.04	0.013096	3.76	24.31	26.81	0.82
Reach-1	8313.3	46.30	109.14	112.07	111.33	112.17	0.002112	1.76	104.24	308.83	0.34
Reach-1	8313.3	39.30	109.14	111.67	111.12	111.86	0.004071	2.20	38.04	93.59	0.46
Reach-1	8313.3	32.60	109.14	111.28	110.88	111.55	0.005904	2.46	20.40	24.53	0.56
Reach-1	8313.3	51.18	109.14	112.35		112.37	0.000726	1.10	190.88	316.04	0.20
Reach-1	8313.3	11.80	109.14	110.14		110.43	0.011601	2.36	4.99	5.80	0.81
Reach-1	8313.3	231.00	109.14	112.82		112.90	0.003134	2.51	341.88	327.98	0.43
Reach-1	8313.35	Bridge									
Reach-1	8313.4	12.00	109.14	110.21	110.04	110.46	0.009409	2.22	5.41	5.80	0.73
Reach-1	8313.4	64.10	109.14	112.04	111.48	112.27	0.004785	2.63	94.18	307.98	0.51
Reach-1	8313.4	56.20	109.14	111.91	111.43	112.09	0.003998	2.33	68.43	153.46	0.46
Reach-1	8313.4	46.30	109.14	112.12	111.33	112.19	0.001604	1.55	121.29	310.26	0.29
Reach-1	8313.4	39.30	109.14	111.74	111.11	111.89	0.003346	2.04	45.06	110.35	0.41
Reach-1	8313.4	32.60	109.14	111.31	110.88	111.56	0.005607	2.41	21.05	24.92	0.54
Reach-1	8313.4	51.18	109.14	112.36	111.39	112.38	0.000699	1.08	193.90	316.29	0.20
Reach-1	8313.4	11.80	109.14	110.20	110.03	110.45	0.009391	2.20	5.35	5.80	0.73
Reach-1	8313.4	231.00	109.14	112.85	112.50	112.93	0.002854	2.41	353.29	328.85	0.41
Reach-1	8313.5	12.00	109.14	110.23	110.04	110.47	0.008868	2.17	5.52	5.80	0.71
Reach-1	8313.5	64.10	109.14	112.02	111.58	112.28	0.005247	2.74	88.69	307.52	0.53
Reach-1	8313.5	56.20	109.14	111.92	111.40	112.09	0.003907	2.31	69.57	155.25	0.45
Reach-1	8313.5	46.30	109.14	112.13	111.15	112.19	0.001592	1.55	121.78	310.30	0.29
Reach-1	8313.5	39.30	109.14	111.53	110.95	111.99	0.008162	3.02	13.02	53.87	0.64
Reach-1	8313.5	32.60	109.14	111.18	110.76	111.63	0.008846	2.95	11.04	23.08	0.68
Reach-1	8313.5	51.18	109.14	112.36	111.27	112.38	0.000697	1.08	194.12	316.31	0.20
Reach-1	8313.5	11.80	109.14	110.22	110.03	110.46	0.008847	2.16	5.46	5.80	0.71
Reach-1	8313.5	231.00	109.14	112.85	111.99	112.93	0.002832	2.41	354.23	328.92	0.41
Reach-1	8313.6	12.00	109.20	110.32		110.52	0.005846	2.02	6.53	7.95	0.64
Reach-1	8313.6	64.10	109.20	111.97		112.33	0.003702	3.08	49.76	56.75	0.60
Reach-1	8313.6	56.20	109.20	111.79		112.19	0.004216	3.13	39.65	50.92	0.63
Reach-1	8313.6	46.30	109.20	112.08		112.23	0.001563	2.05	67.05	212.62	0.39
Reach-1	8313.6	39.30	109.20	111.87		112.04	0.001711	2.04	44.24	53.65	0.41
Reach-1	8313.6	32.60	109.20	111.43		111.68	0.002916	2.34	23.92	32.53	0.51
Reach-1	8313.6	51.18	109.20	112.32		112.40	0.000927	1.67	124.99	261.73	0.31
Reach-1	8313.6	11.80	109.20	110.31		110.51	0.005870	2.01	6.44	7.92	0.64
Reach-1	8313.6	231.00	109.20	112.65		113.22	0.007467	5.08	221.36	310.82	0.89
Reach-1	8450	12.00	110.28	111.43	111.43	111.67	0.019045	2.19	5.49	11.45	1.01
Reach-1	8450	64.10	110.28	112.34	112.34	112.82	0.013253	3.18	25.84	30.59	0.97
Reach-1	8450	56.20	110.28	112.25	112.25	112.70	0.013279	3.07	23.09	29.16	0.96
Reach-1	8450	46.30	110.28	112.13	112.12	112.53	0.013193	2.91	19.62	27.24	0.94
Reach-1	8450	39.30	110.28	112.02	112.02	112.40	0.013589	2.81	16.81	25.57	0.95
Reach-1	8450	32.60	110.28	111.90	111.90	112.27	0.014526	2.72	13.85	23.08	0.96

HEC-RAS Plan: 1adv River: RIVER-1 Reach: Reach-1 (Continued)

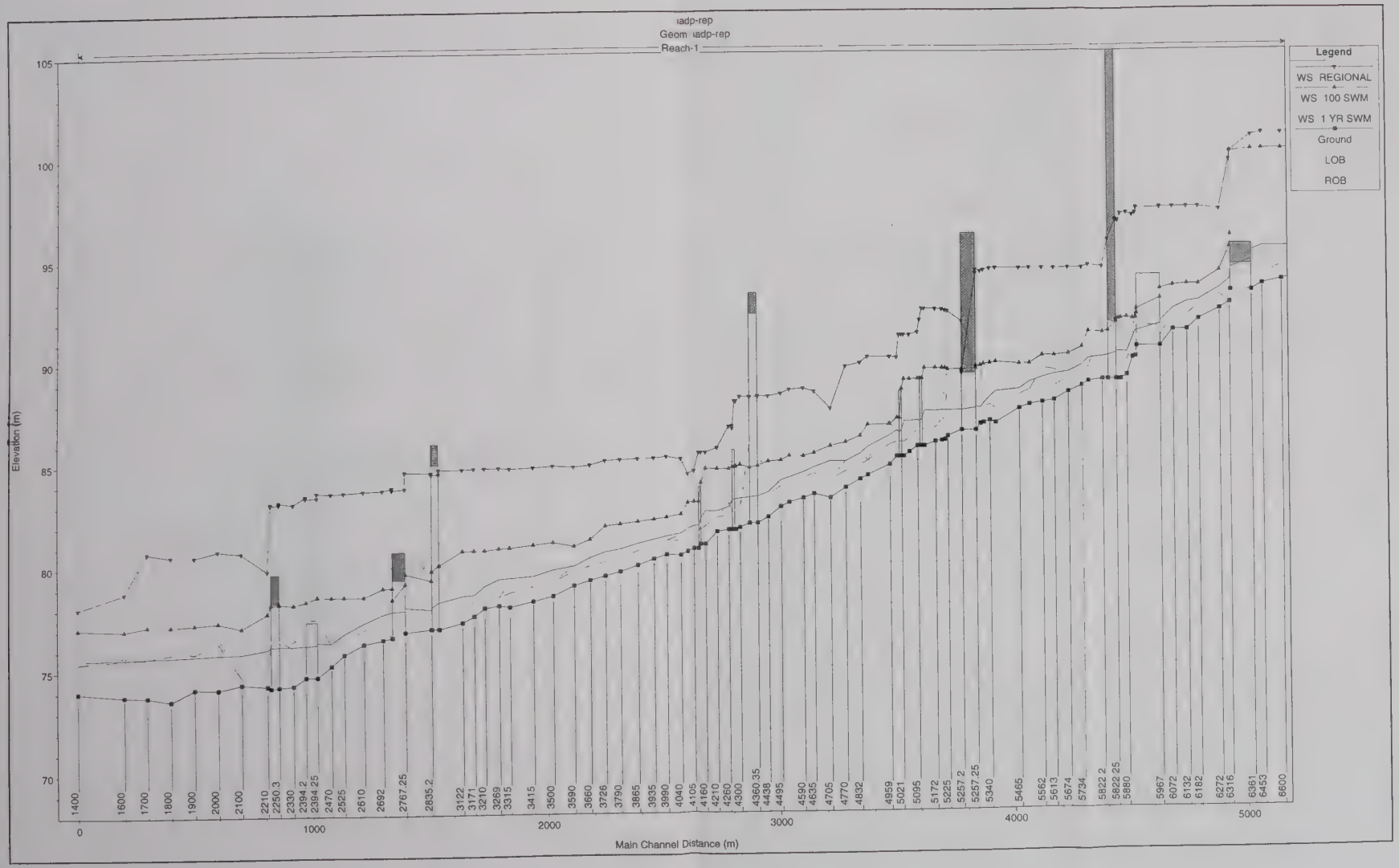
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	8450	51.18	110.28	112.28		112.63	0.010163	2.72	23.90	29.58	0.84
Reach-1	8450	11.80	110.28	111.42	111.42	111.66	0.019155	2.18	5.42	11.41	1.01
Reach-1	8450	231.00	110.28	113.74	113.74	114.31	0.007363	3.83	124.00	147.35	0.81
Reach-1	8500	12.00	111.67	112.41	112.41	112.61	0.018497	1.96	6.12	15.24	0.99
Reach-1	8500	64.10	111.67	113.16	113.16	113.64	0.014366	3.08	20.84	42.03	1.00
Reach-1	8500	56.20	111.67	113.07	113.07	113.52	0.015008	2.98	18.87	40.29	1.01
Reach-1	8500	46.30	111.67	112.96	112.96	113.36	0.015186	2.79	16.58	37.60	1.00
Reach-1	8500	39.30	111.67	112.87	112.87	113.23	0.015648	2.66	14.77	34.57	1.00
Reach-1	8500	32.60	111.67	112.78	112.78	113.10	0.016304	2.52	12.93	31.42	1.00
Reach-1	8500	51.18	111.67	113.01	113.01	113.44	0.015310	2.90	17.65	39.20	1.01
Reach-1	8500	11.80	111.67	112.41	112.40	112.60	0.018259	1.94	6.07	15.19	0.98
Reach-1	8500	231.00	111.67	114.26	114.26	114.92	0.009966	3.97	95.20	99.56	0.92
Reach-1	8550	12.00	112.57	113.37	113.36	113.58	0.018648	2.01	5.98	13.99	0.98
Reach-1	8550	64.10	112.57	114.30	114.30	114.74	0.011978	2.99	25.90	37.04	0.91
Reach-1	8550	56.20	112.57	114.20	114.20	114.63	0.012179	2.92	22.24	35.68	0.91
Reach-1	8550	46.30	112.57	113.99	113.99	114.46	0.014972	3.03	15.27	15.97	0.99
Reach-1	8550	39.30	112.57	113.87	113.87	114.31	0.016037	2.93	13.41	15.59	1.01
Reach-1	8550	32.60	112.57	113.77	113.77	114.16	0.016612	2.78	11.74	15.25	1.01
Reach-1	8550	51.18	112.57	114.12	114.12	114.55	0.012532	2.90	19.57	34.65	0.92
Reach-1	8550	11.80	112.57	113.37	113.36	113.57	0.018826	2.00	5.90	13.97	0.98
Reach-1	8550	231.00	112.57	115.49	115.49	116.25	0.009621	4.23	94.65	87.95	0.91
Reach-1	8600	12.00	113.72	114.37	114.37	114.59	0.018717	2.04	5.88	14.15	1.01
Reach-1	8600	64.10	113.72	115.18	115.18	115.67	0.013801	3.10	20.87	22.92	1.00
Reach-1	8600	56.20	113.72	115.10	115.10	115.55	0.014340	2.97	18.96	22.03	1.00
Reach-1	8600	46.30	113.72	114.98	114.98	115.39	0.015151	2.81	16.50	20.81	1.01
Reach-1	8600	39.30	113.72	114.89	114.89	115.26	0.015578	2.71	14.50	19.69	1.01
Reach-1	8600	32.60	113.72	114.79	114.79	115.13	0.015736	2.58	12.62	18.58	1.00
Reach-1	8600	51.18	113.72	115.04	115.04	115.47	0.015002	2.90	17.64	21.39	1.01
Reach-1	8600	11.80	113.72	114.37	114.37	114.58	0.018750	2.03	5.81	14.09	1.01
Reach-1	8600	231.00	113.72	116.54	116.54	117.37	0.008091	4.23	82.99	73.59	0.88
Reach-1	8650	12.00	114.64	115.39	115.39	115.60	0.018532	2.04	5.88	14.12	1.01
Reach-1	8650	64.10	114.64	116.18	116.18	116.62	0.012946	2.96	22.98	33.17	0.97
Reach-1	8650	56.20	114.64	116.09	116.09	116.51	0.013999	2.88	20.15	29.37	0.99
Reach-1	8650	46.30	114.64	115.98	115.98	116.35	0.014654	2.71	17.27	25.30	0.99
Reach-1	8650	39.30	114.64	115.89	115.89	116.24	0.015347	2.60	15.14	23.15	1.00
Reach-1	8650	32.60	114.64	115.80	115.80	116.12	0.016163	2.49	13.09	21.05	1.01
Reach-1	8650	51.18	114.64	116.03	116.03	116.43	0.014545	2.81	18.58	27.04	1.00
Reach-1	8650	11.80	114.64	115.38	115.38	115.59	0.018576	2.03	5.80	14.02	1.01
Reach-1	8650	231.00	114.64	117.36	117.36	118.13	0.008713	4.17	83.90	67.83	0.91
Reach-1	8700	12.00	115.52	116.25		116.45	0.015648	1.99	6.04	13.13	0.93
Reach-1	8700	64.10	115.52	117.13	117.13	117.70	0.012952	3.35	19.80	21.61	0.98
Reach-1	8700	56.20	115.52	117.02	117.02	117.55	0.013495	3.24	17.53	19.68	0.99
Reach-1	8700	46.30	115.52	116.87	116.87	117.36	0.014535	3.10	14.95	15.86	1.01
Reach-1	8700	39.30	115.52	116.76	116.76	117.21	0.014709	2.94	13.36	15.18	1.00
Reach-1	8700	32.60	115.52	116.65	116.65	117.05	0.015465	2.81	11.61	14.71	1.01
Reach-1	8700	51.18	115.52	116.94	116.94	117.46	0.013972	3.17	16.20	16.72	1.00
Reach-1	8700	11.80	115.52	116.24		116.44	0.015568	1.97	5.99	13.12	0.93
Reach-1	8700	231.00	115.52	118.67	118.67	119.42	0.006928	4.20	107.21	98.48	0.82

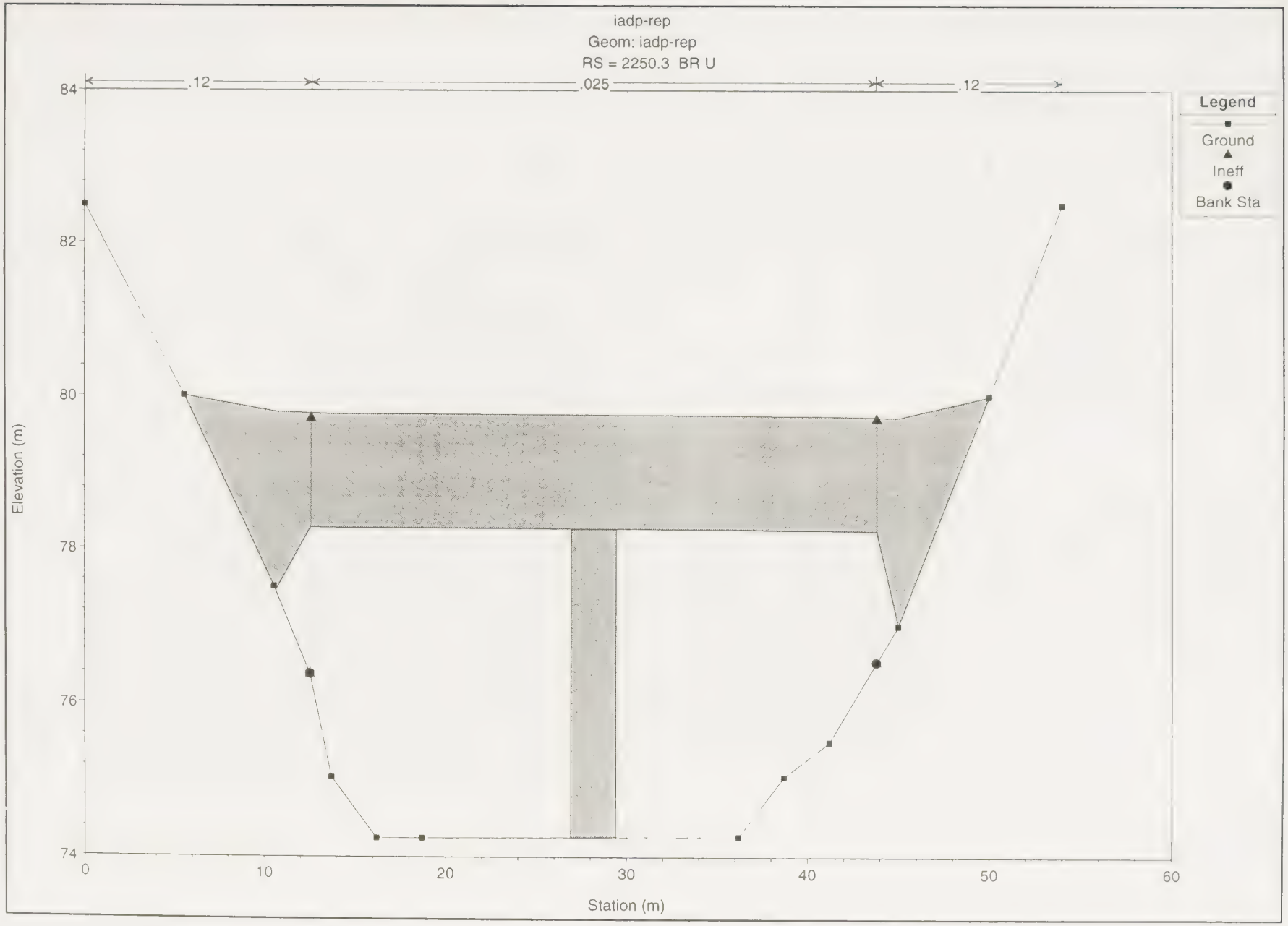
APPENDIX C

RED HILL CREEK EXPRESSWAY
(MUD ST. TO BRAMPTON ST. SECTION)

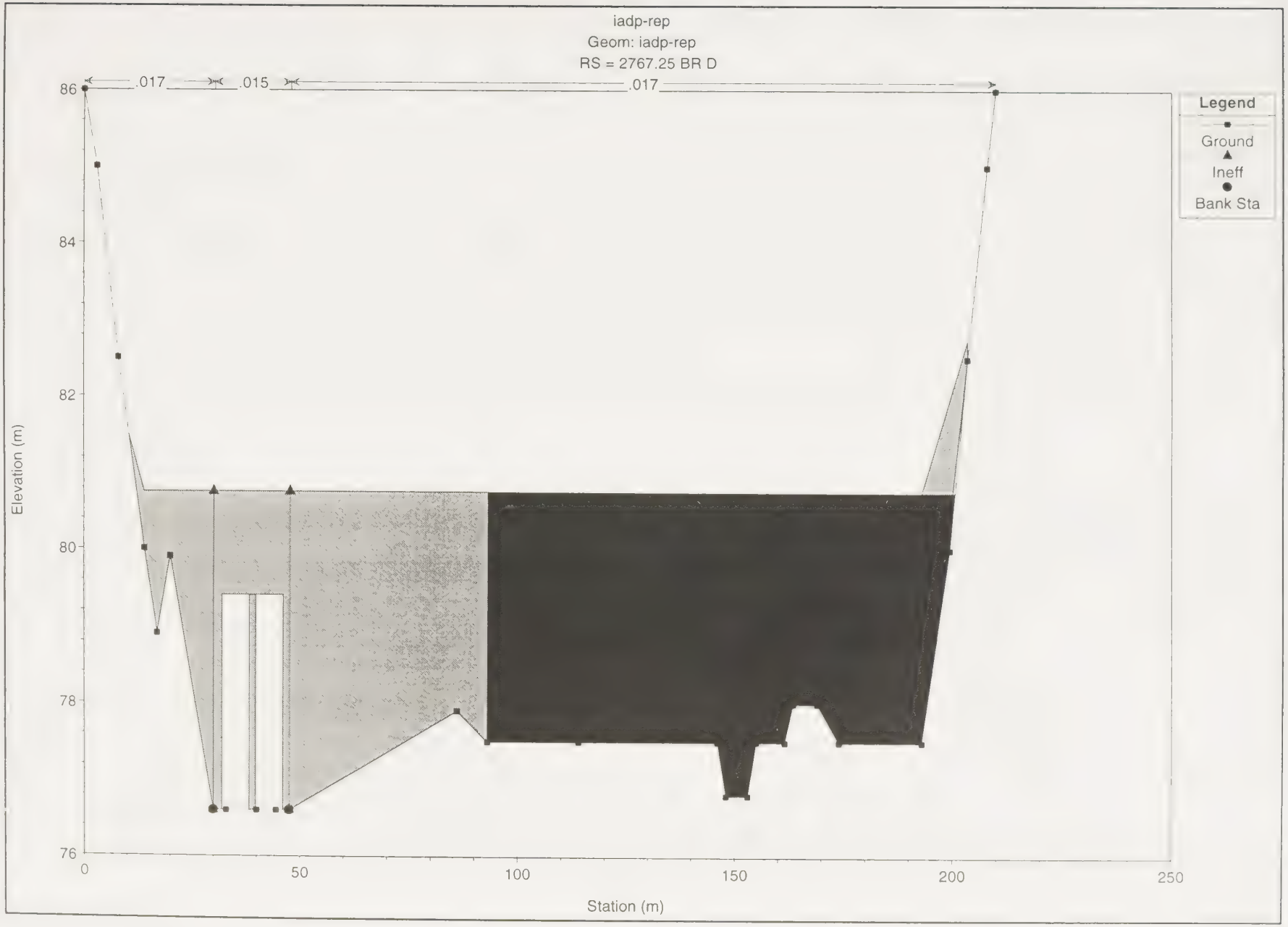
HYDRAULIC MODEL RESULTS

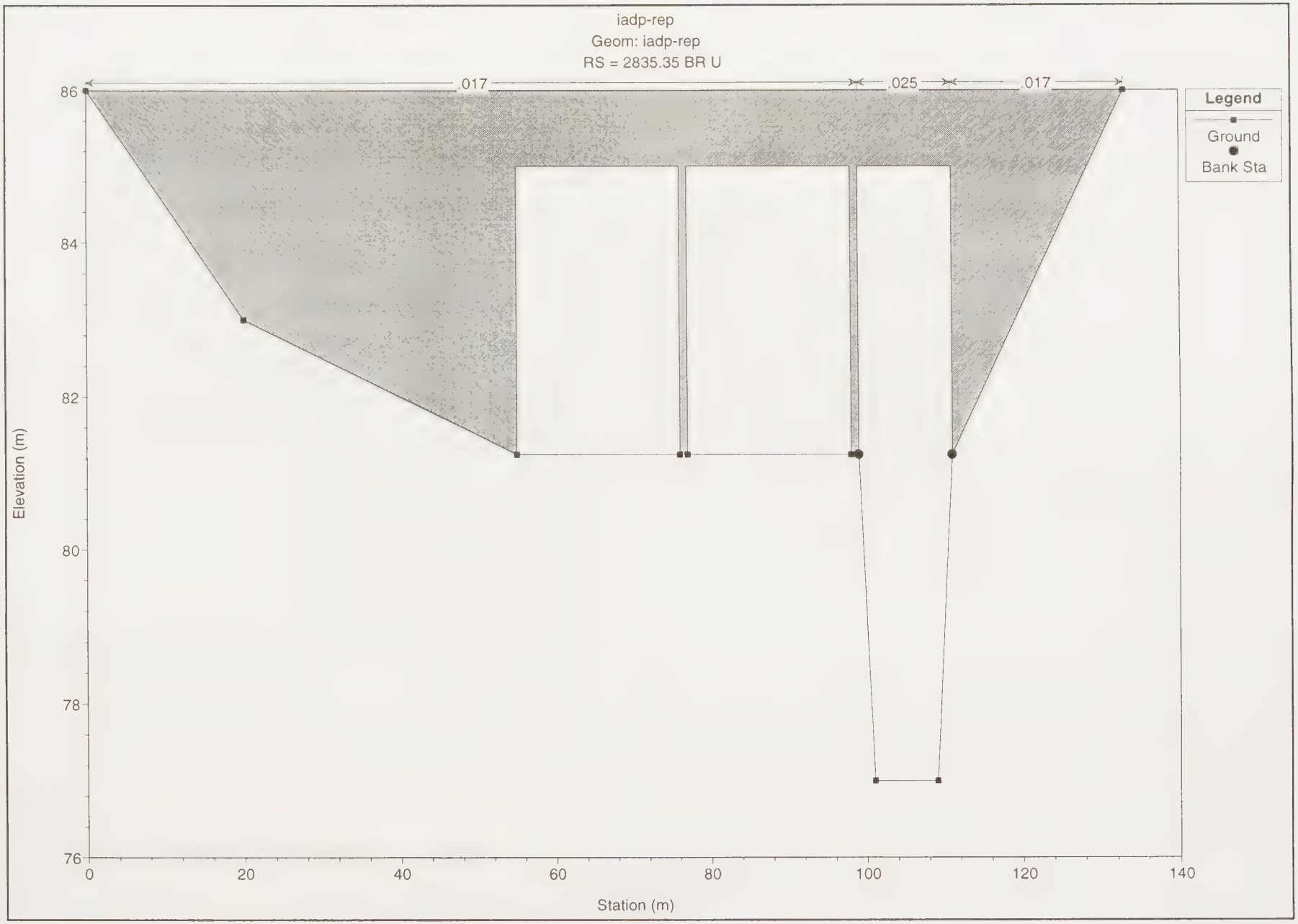
FUTURE EXPRESSWAY CONDITIONS

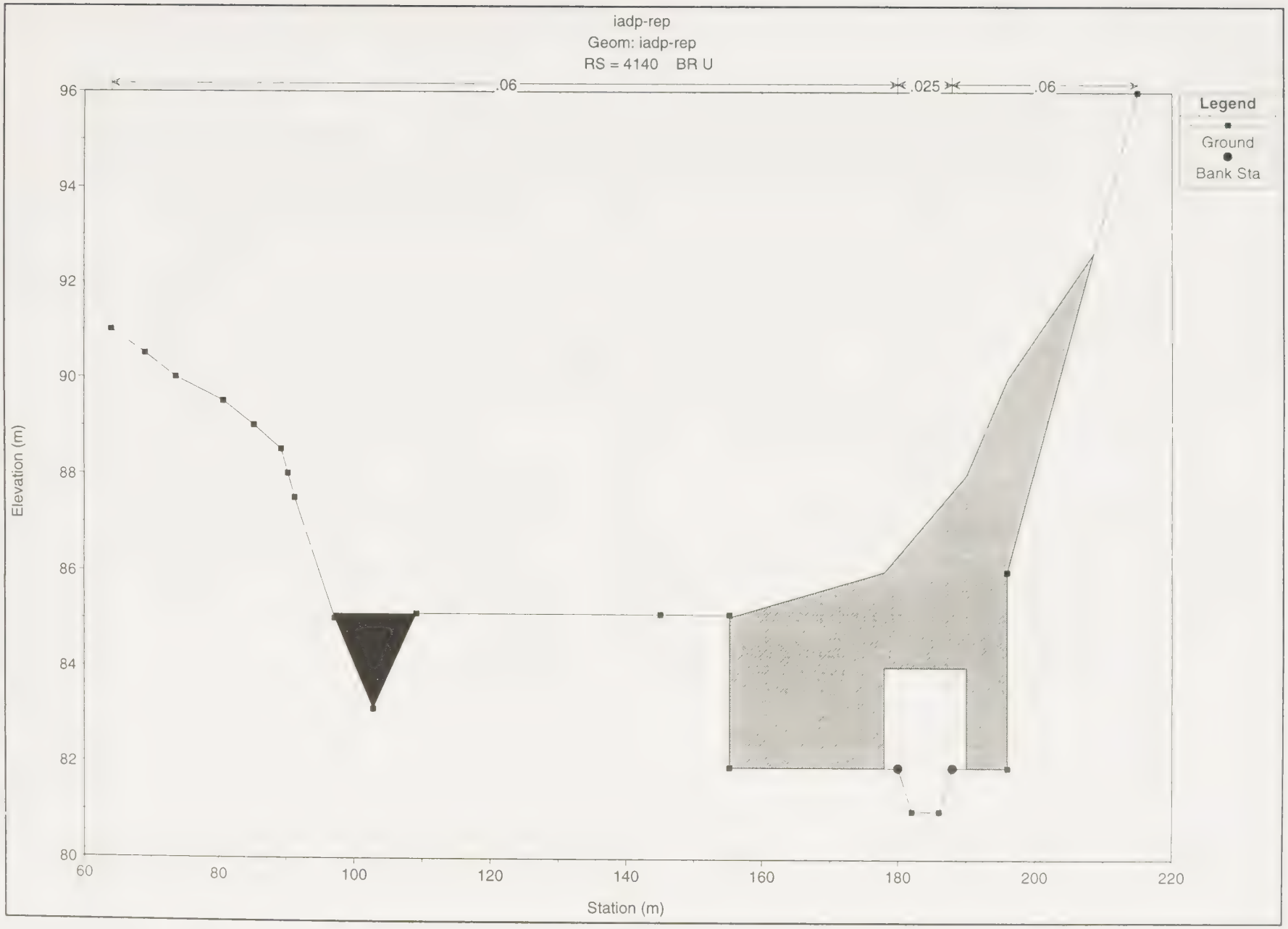

adp-rep
Geom adp-rep
Reach-1
Legend
WS REGIONAL
WS 100 SWM
WS 1 YR SWM
Ground
LOB
ROB
Elevation (m)
105
100
95
90
85
80
75
70
0
1000
2000
3000
4000
5000
Main Channel Distance (m)
1400
1600
1700
1800
1900
2000
2100
2210
2250.3
2330
2394.2
2394.25
2470
2525
2610
2692
2767.25
2835.2
3122
3171
3210
3269
3315
3415
3500
3590
3660
3726
3790
3865
3935
3990
4040
4105
4160
4210
4260
4300
4360.35
4438
4495
4590
4635
4705
4770
4832
4959
5021
5095
5172
5225
5257.2
5257.25
5340
5465
5562
5613
5674
5734
5822.2
5822.25
5880
5967
6072
6132
6182
6272
6316
6361
6453
6600

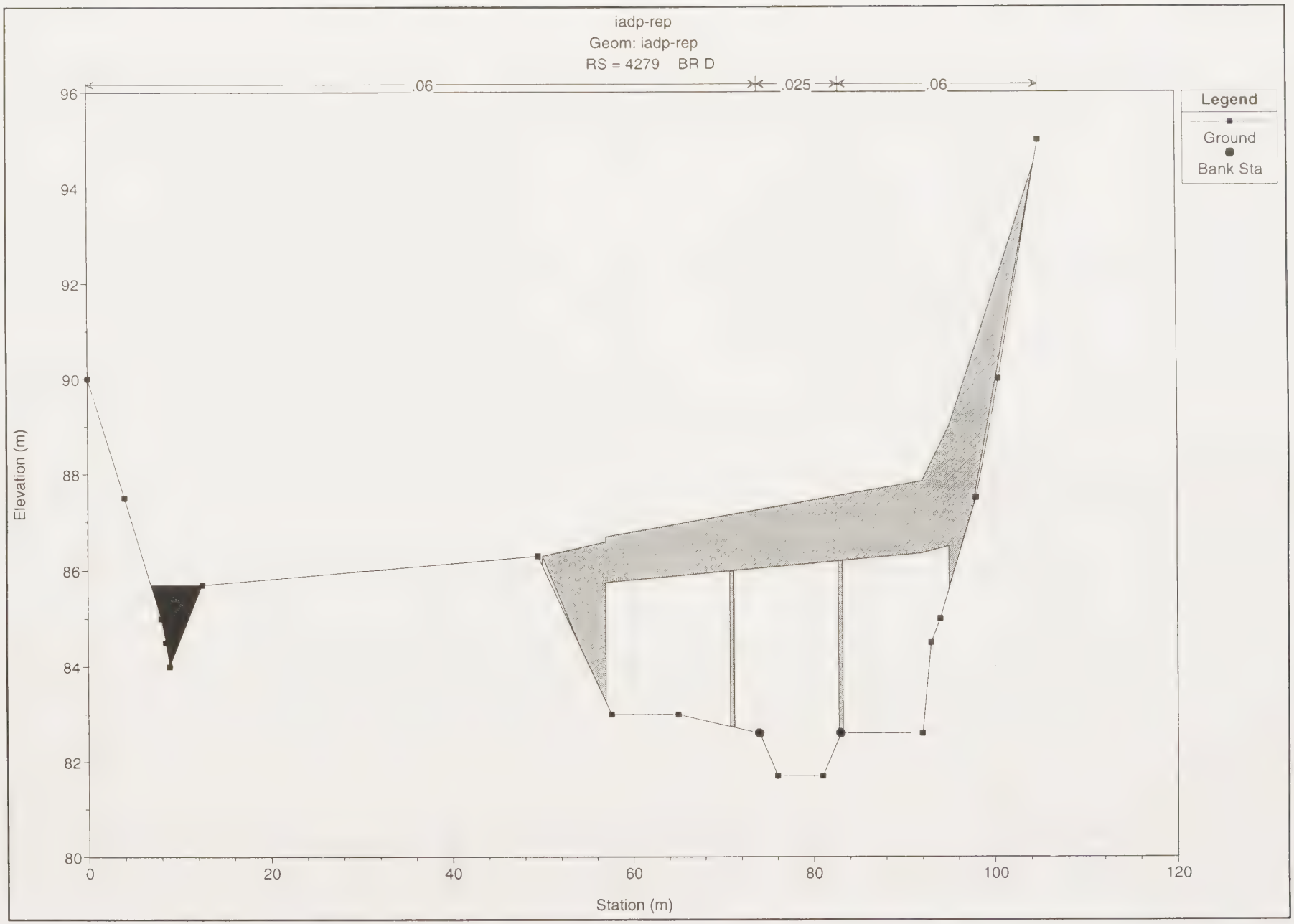

iadp-rep
Geom: iadp-rep
RS = 2250.3 BR U
.12
.025
.12
Legend
Ground
Ineff
Bank Sta
Elevation (m)
84
82
80
78
76
74
0
10
20
30
40
50
60
Station (m)

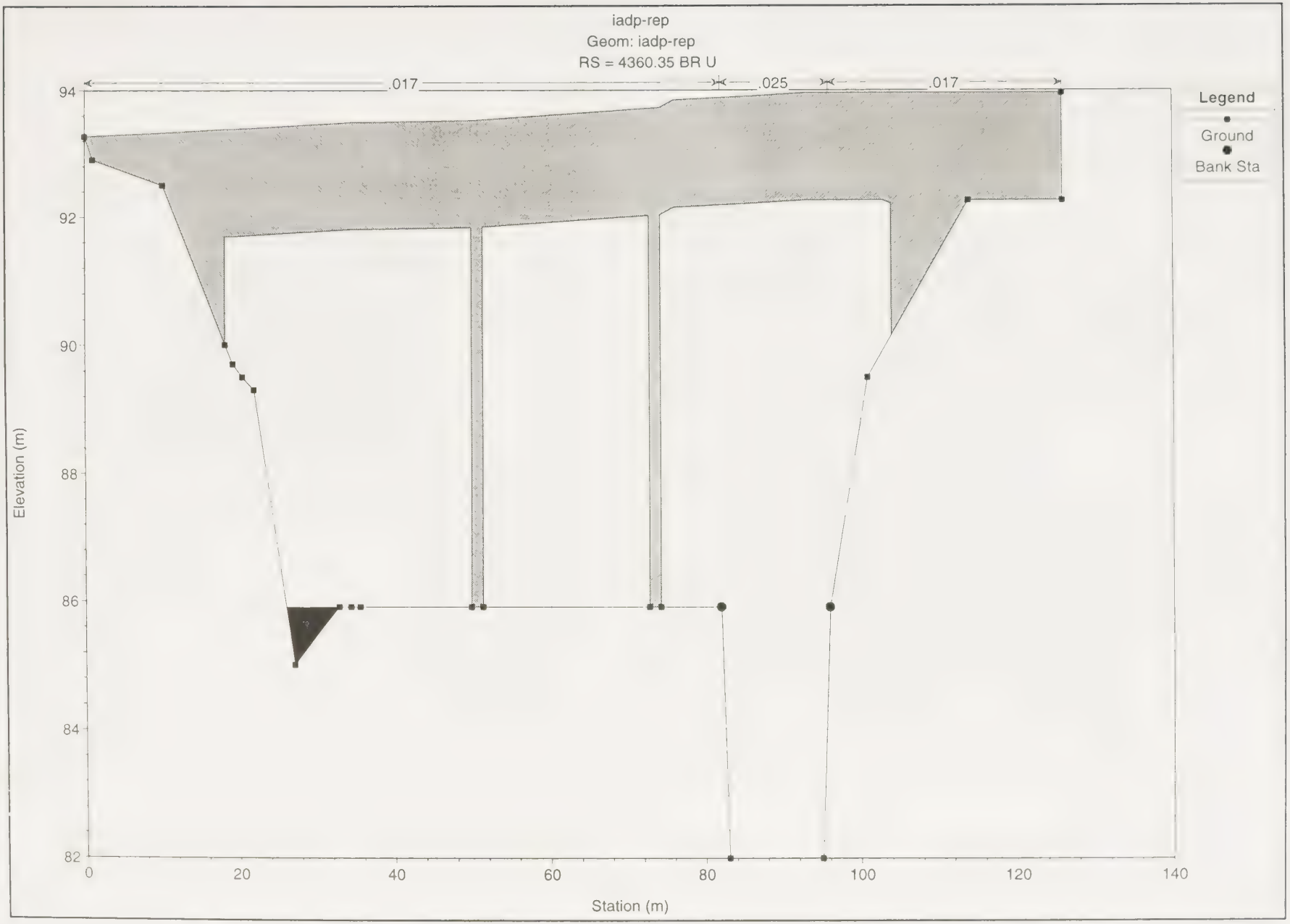

iadp-rep
Geom: iadp-rep
RS = 2394.25 BR U
.017
.022
.017
Legend
Ground
Bank Sta
Elevation (m)
86
84
82
80
78
76
74
0
50
100
150
200
250
Station (m)

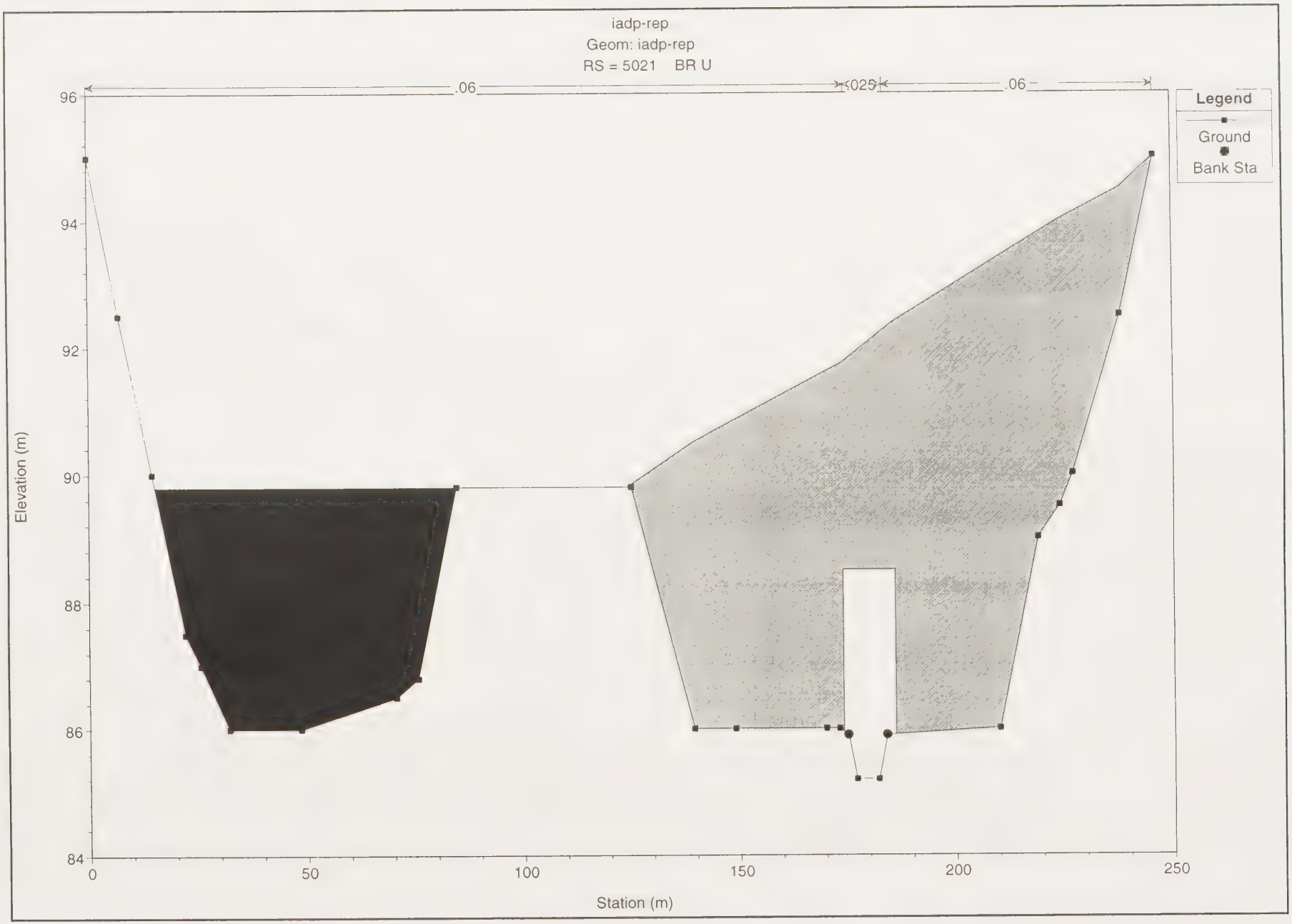

iadp-rep
Geom: iadp-rep
RS = 2767.25 BR D
.017
.015
.017
Legend
Ground
Ineff
Bank Sta
Elevation (m)
86
84
82
80
78
76
0
50
100
150
200
250
Station (m)

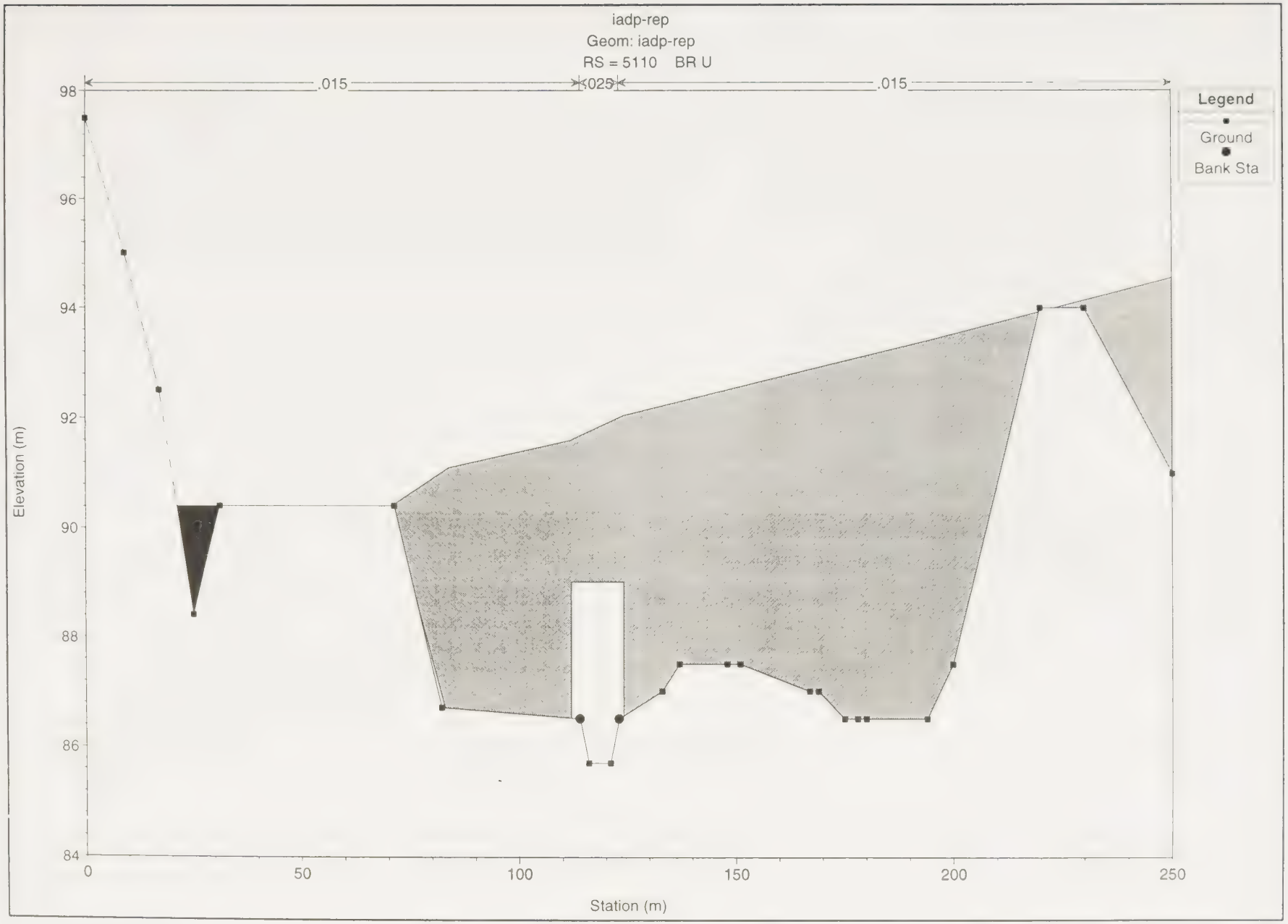

iadp-rep
Geom: iadp-rep
RS = 2835.35 BR U
.017
.025
.017
Legend
Ground
Bank Sta
Elevation (m)
86
84
82
80
78
76
0
20
40
60
80
100
120
140
Station (m)

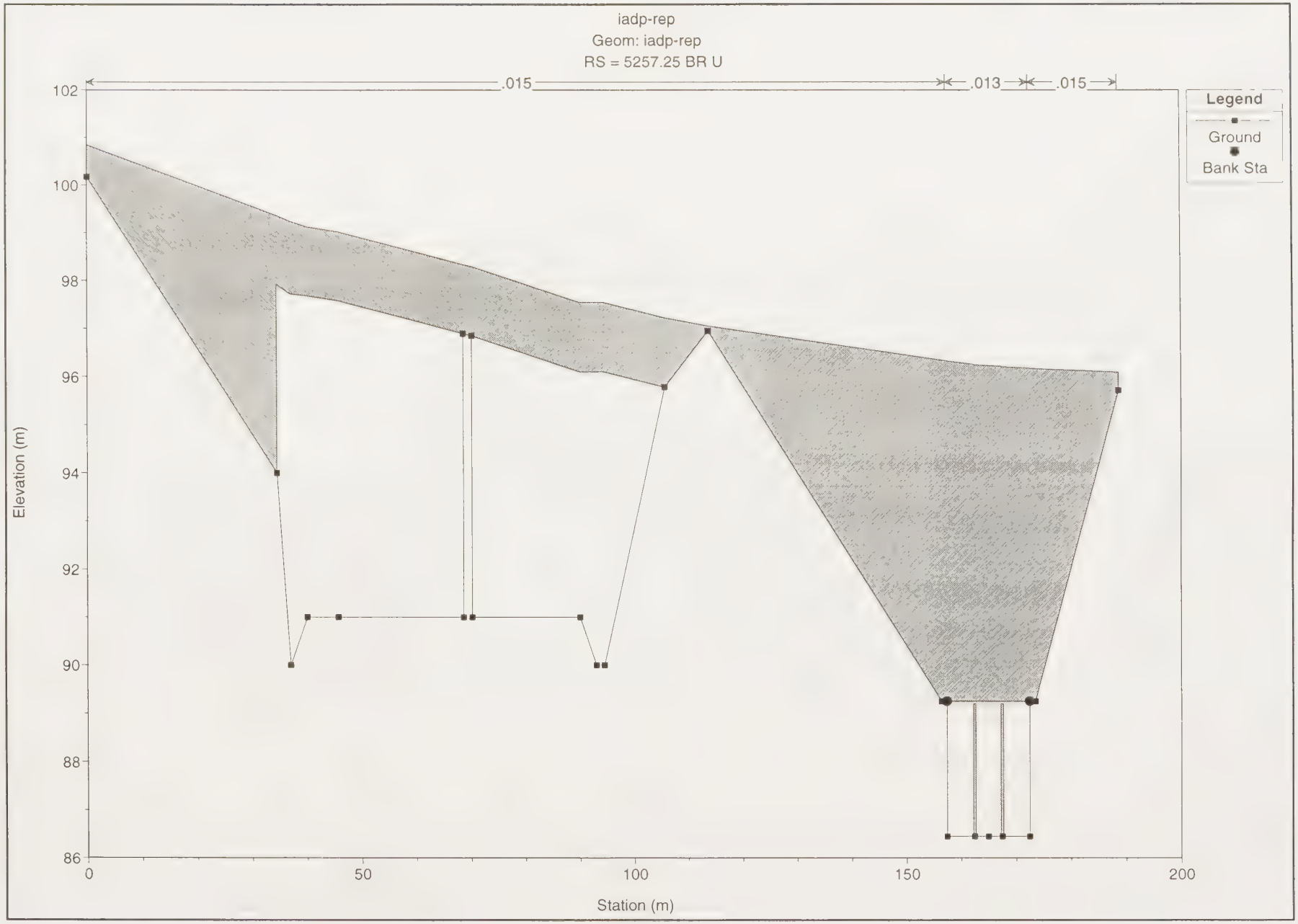

iadp-rep
Geom: iadp-rep
RS = 4140 BR U
.06
.025
.06
Legend
Ground
Bank Sta
Elevation (m)
96
94
92
90
88
86
84
82
80
60
80
100
120
140
160
180
200
220
Station (m)

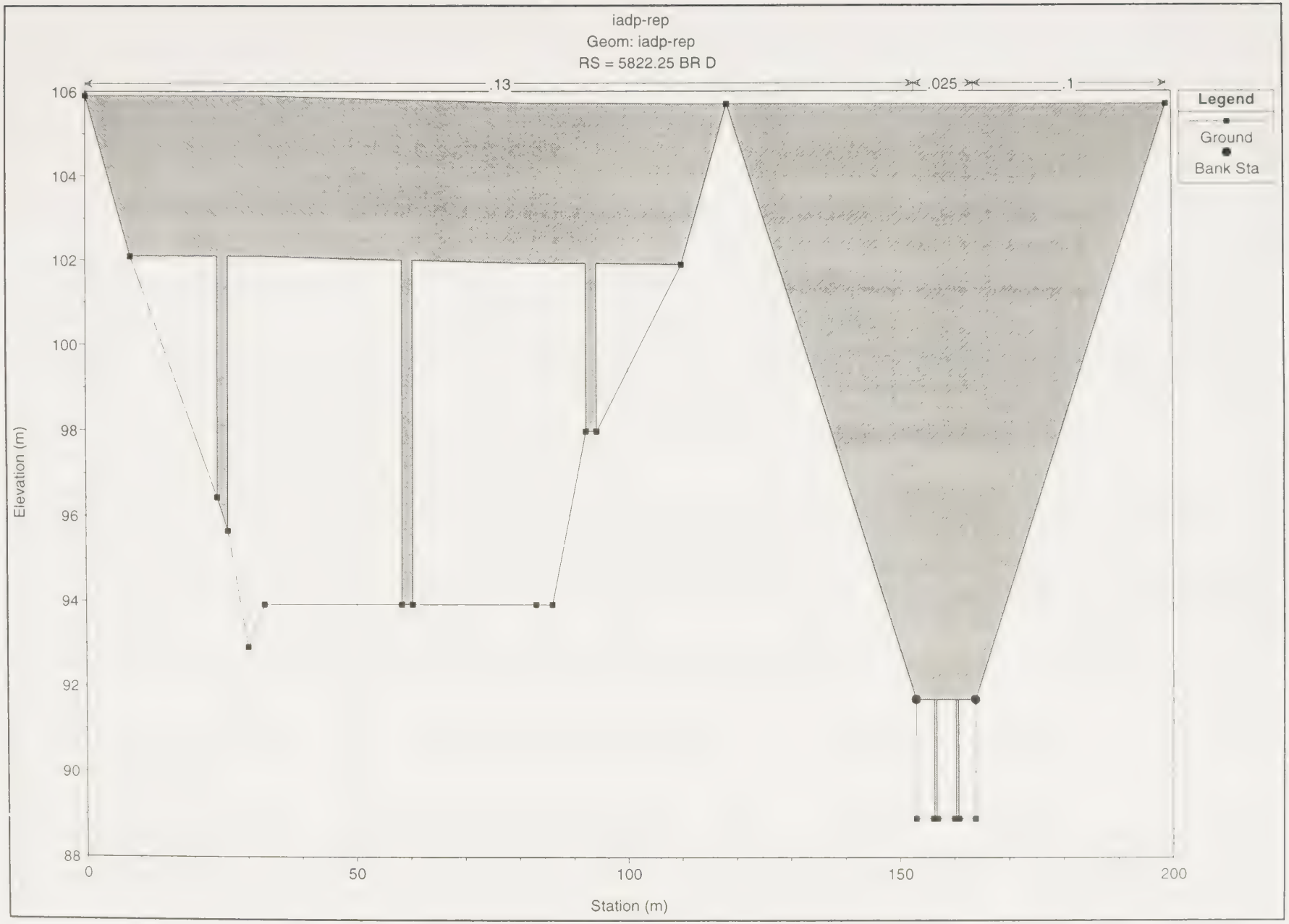

iadp-rep
Geom: iadp-rep
RS = 4279 BR D
.06
.025
.06
Legend
Ground
Bank Sta
96
94
92
90
88
86
84
82
80
Elevation (m)
0
20
40
60
80
100
120
Station (m)


iadp-rep
Geom: iadp-rep
RS = 4360.35 BR U
.017
.025
.017
Legend
Ground
Bank Sta
Elevation (m)
94
92
90
88
86
84
82
0
20
40
60
80
100
120
140
Station (m)


iadp-rep
Geom: iadp-rep
RS = 5021 BR U
.06
.025
.06
Legend
Ground
Bank Sta
96
94
92
90
88
86
84
Elevation (m)
0
50
100
150
200
250
Station (m)


iadp-rep
Geom: iadp-rep
RS = 5110 BR U
.015
.025
.015
Legend
Ground
Bank Sta
Elevation (m)
98
96
94
92
90
88
86
84
0
50
100
150
200
250
Station (m)


iadp-rep
Geom: iadp-rep
RS = 5257.25 BR U
.015
.013
.015
Legend
Ground
Bank Sta
Elevation (m)
Station (m)
102
100
98
96
94
92
90
88
86
0
50
100
150
200


iadp-rep
Geom: iadp-rep
RS = 5822.25 BR D
.13
.025
.1
Legend
Ground
Bank Sta
Elevation (m)
106
104
102
100
98
96
94
92
90
88
0
50
100
150
200
Station (m)

HEC-RAS Plan: iadp-rep River: RIVER-1 Reach: Reach-1

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	1400	22.10	74.01	75.60	74.73	75.63	0.000281	0.78	41.76	128.10	0.22
Reach-1	1400	46.40	74.01	76.20	75.06	76.24	0.000238	0.93	119.74	131.51	0.22
Reach-1	1400	60.60	74.01	76.60	75.23	76.63	0.000178	0.91	172.66	133.61	0.19
Reach-1	1400	70.20	74.01	76.75	75.33	76.78	0.000183	0.96	192.68	134.50	0.20
Reach-1	1400	79.40	74.01	76.85	75.42	76.89	0.000198	1.03	206.24	135.11	0.21
Reach-1	1400	91.40	74.01	76.95	75.69	76.99	0.000223	1.12	219.86	135.71	0.22
Reach-1	1400	101.00	74.01	77.09	75.76	77.14	0.000220	1.15	238.94	136.55	0.22
Reach-1	1400	21.50	74.01	75.60	74.72	75.63	0.000266	0.76	41.76	128.10	0.21
Reach-1	1400	493.00	74.01	78.07	77.23	78.52	0.001548	3.74	375.21	140.14	0.62
Reach-1	1600	22.10	73.84	75.65		75.70	0.000422	0.99	22.32	15.92	0.27
Reach-1	1600	46.40	73.84	76.22		76.33	0.000605	1.48	31.86	17.64	0.34
Reach-1	1600	60.60	73.84	76.59		76.72	0.000578	1.62	38.53	18.72	0.34
Reach-1	1600	70.20	73.84	76.72		76.88	0.000640	1.77	41.13	19.29	0.36
Reach-1	1600	79.40	73.84	76.81		77.00	0.000727	1.93	42.85	19.65	0.39
Reach-1	1600	91.40	73.84	76.90		77.13	0.000864	2.15	44.51	20.00	0.42
Reach-1	1600	101.00	73.84	77.02		77.28	0.000904	2.27	47.02	20.51	0.44
Reach-1	1600	21.50	73.84	75.65		75.70	0.000402	0.97	22.27	15.91	0.26
Reach-1	1600	493.00	73.84	78.83	78.83	80.99	0.003871	6.57	89.50	26.25	0.98
Reach-1	1700	22.10	73.81	75.71		75.74	0.000322	0.81	27.14	22.47	0.23
Reach-1	1700	46.40	73.81	76.32		76.38	0.000371	1.14	42.43	28.94	0.27
Reach-1	1700	60.60	73.81	76.69		76.77	0.000336	1.23	54.37	34.23	0.26
Reach-1	1700	70.20	73.81	76.85		76.94	0.000357	1.33	59.85	36.40	0.28
Reach-1	1700	79.40	73.81	76.96		77.06	0.000391	1.43	64.00	37.97	0.29
Reach-1	1700	91.40	73.81	77.08		77.20	0.000440	1.57	68.60	38.77	0.31
Reach-1	1700	101.00	73.81	77.22		77.36	0.000446	1.64	74.16	39.24	0.32
Reach-1	1700	21.50	73.81	75.70		75.74	0.000309	0.80	27.02	22.43	0.23
Reach-1	1700	493.00	73.81	80.78		81.27	0.000583	3.26	233.72	48.50	0.41
Reach-1	1800	22.10	73.61	75.73		75.79	0.000447	1.04	21.21	14.47	0.27
Reach-1	1800	46.40	73.61	76.33		76.45	0.000648	1.52	34.80	31.20	0.35
Reach-1	1800	60.60	73.61	76.70		76.83	0.000604	1.65	46.93	33.71	0.34
Reach-1	1800	70.20	73.61	76.85		77.01	0.000648	1.78	52.08	34.05	0.36
Reach-1	1800	79.40	73.61	76.96		77.14	0.000711	1.92	55.81	34.29	0.38
Reach-1	1800	91.40	73.61	77.07		77.29	0.000807	2.10	59.80	34.70	0.41
Reach-1	1800	101.00	73.61	77.21		77.45	0.000826	2.20	64.62	35.28	0.41
Reach-1	1800	21.50	73.61	75.72		75.78	0.000428	1.02	21.12	14.45	0.27
Reach-1	1800	493.00	73.61	80.59		81.47	0.001204	4.46	215.46	57.93	0.57
Reach-1	1900	22.20	74.18	75.78		75.84	0.000631	1.12	19.78	15.94	0.32
Reach-1	1900	46.30	74.18	76.39		76.52	0.000722	1.55	30.61	19.22	0.37
Reach-1	1900	60.30	74.18	76.75		76.90	0.000669	1.69	37.86	20.94	0.36
Reach-1	1900	69.60	74.18	76.91		77.08	0.000708	1.82	41.17	21.68	0.38
Reach-1	1900	78.60	74.18	77.02		77.22	0.000769	1.95	43.67	22.22	0.40
Reach-1	1900	90.00	74.18	77.15		77.38	0.000853	2.13	46.48	22.82	0.42
Reach-1	1900	99.00	74.18	77.29		77.53	0.000864	2.22	49.69	23.48	0.43
Reach-1	1900	21.40	74.18	75.77		75.83	0.000598	1.09	19.65	15.92	0.31
Reach-1	1900	490.00	74.18	80.58		81.65	0.001371	4.73	151.27	38.14	0.62
Reach-1	2000	22.20	74.15	75.84		75.91	0.000753	1.22	18.27	14.90	0.35
Reach-1	2000	46.30	74.15	76.47		76.60	0.000927	1.63	28.35	17.27	0.41
Reach-1	2000	60.30	74.15	76.82		76.98	0.000835	1.75	34.72	18.67	0.40
Reach-1	2000	69.60	74.15	76.98		77.16	0.000859	1.87	37.75	19.41	0.41
Reach-1	2000	78.60	74.15	77.10		77.30	0.000913	1.99	40.13	20.15	0.42
Reach-1	2000	90.00	74.15	77.23		77.47	0.000987	2.15	42.88	21.02	0.44
Reach-1	2000	99.00	74.15	77.37		77.63	0.000986	2.24	45.89	21.93	0.45
Reach-1	2000	21.40	74.15	75.83		75.90	0.000718	1.18	18.10	14.86	0.34
Reach-1	2000	490.00	74.15	80.87		81.80	0.001203	4.40	167.00	47.58	0.57
Reach-1	2100	22.20	74.40	75.86		76.06	0.001790	2.02	14.79	15.48	0.56
Reach-1	2100	46.30	74.40	76.42		76.82	0.002250	2.87	24.49	19.11	0.67
Reach-1	2100	60.30	74.40	76.73		77.20	0.002239	3.17	30.63	21.09	0.69
Reach-1	2100	69.60	74.40	76.85		77.40	0.002448	3.44	33.32	21.90	0.72
Reach-1	2100	78.60	74.40	76.94		77.58	0.002756	3.74	35.14	22.44	0.77
Reach-1	2100	90.00	74.40	77.01		77.80	0.003234	4.13	36.85	22.93	0.84
Reach-1	2100	99.00	74.40	77.11		77.98	0.003395	4.35	39.18	23.57	0.87
Reach-1	2100	21.40	74.40	75.85		76.04	0.001716	1.97	14.61	15.40	0.55
Reach-1	2100	490.00	74.40	80.75	80.75	83.03	0.003194	7.61	167.77	47.15	0.98
Reach-1	2210	22.20	74.30	76.08		76.19	0.000741	1.48	18.29	15.73	0.37
Reach-1	2210	46.30	74.30	76.77		76.99	0.000948	2.12	30.54	19.99	0.44

HEC-RAS Plan: jadp rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	2210	60.30	74.30	77.11		77.38	0.000994	2.38	37.66	22.09	0.47
Reach-1	2210	69.60	74.30	77.29		77.60	0.001047	2.55	41.78	23.21	0.48
Reach-1	2210	78.60	74.30	77.45		77.80	0.001098	2.71	45.58	24.21	0.50
Reach-1	2210	90.00	74.30	77.65		78.04	0.001143	2.88	50.55	25.45	0.51
Reach-1	2210	99.00	74.30	77.81		78.23	0.001159	3.00	54.73	26.45	0.52
Reach-1	2210	21.40	74.30	76.06		76.17	0.000721	1.45	17.95	15.59	0.36
Reach-1	2210	490.00	74.30	79.87	79.87	83.00	0.004920	8.51	122.44	39.25	1.17
Reach-1	2250.2	22.20	74.20	76.19	74.72	76.20	0.000064	0.44	50.51	30.30	0.11
Reach-1	2250.2	46.30	74.20	76.99	75.01	77.01	0.000077	0.62	75.26	33.58	0.13
Reach-1	2250.2	60.30	74.20	77.38	75.16	77.41	0.000079	0.69	87.50	34.93	0.13
Reach-1	2250.2	69.60	74.20	77.60	75.25	77.63	0.000082	0.74	94.40	35.71	0.14
Reach-1	2250.2	78.60	74.20	77.80	75.33	77.83	0.000084	0.78	100.59	36.43	0.14
Reach-1	2250.2	90.00	74.20	78.04	75.42	78.08	0.000087	0.83	108.22	37.32	0.14
Reach-1	2250.2	99.00	74.20	78.23	75.50	78.27	0.000088	0.87	114.19	38.02	0.14
Reach-1	2250.2	21.40	74.20	76.17	74.71	76.18	0.000062	0.43	49.70	30.21	0.11
Reach-1	2250.2	490.00	74.20	83.15	77.51	83.30	0.000117	1.77	351.25	54.00	0.19
Reach-1	2250.3	Bridge									
Reach-1	2250.4	22.20	74.25	76.22	74.74	76.23	0.000063	0.44	50.82	30.40	0.11
Reach-1	2250.4	46.30	74.25	77.02	75.04	77.04	0.000076	0.61	75.59	33.68	0.13
Reach-1	2250.4	60.30	74.25	77.41	75.18	77.43	0.000078	0.69	87.86	35.03	0.13
Reach-1	2250.4	69.60	74.25	77.63	75.27	77.66	0.000080	0.73	94.77	35.82	0.13
Reach-1	2250.4	78.60	74.25	77.83	75.35	77.86	0.000083	0.78	101.03	36.55	0.14
Reach-1	2250.4	90.00	74.25	78.07	75.45	78.11	0.000085	0.83	108.60	37.44	0.14
Reach-1	2250.4	99.00	74.25	78.27	75.52	78.31	0.000086	0.86	114.70	38.15	0.14
Reach-1	2250.4	21.40	74.25	76.20	74.73	76.21	0.000061	0.43	50.01	30.30	0.11
Reach-1	2250.4	490.00	74.25	83.22	77.52	83.37	0.000114	1.76	354.65	54.00	0.19
Reach-1	2330	22.20	74.30	76.21		76.25	0.000389	0.94	23.59	17.60	0.26
Reach-1	2330	46.30	74.30	76.99		77.06	0.000376	1.23	39.34	22.44	0.27
Reach-1	2330	60.30	74.30	77.37		77.46	0.000360	1.35	48.26	23.87	0.27
Reach-1	2330	69.60	74.30	77.59		77.69	0.000362	1.43	53.49	24.59	0.28
Reach-1	2330	78.60	74.30	77.78		77.90	0.000363	1.50	58.34	25.15	0.28
Reach-1	2330	90.00	74.30	78.02		78.15	0.000365	1.58	64.36	25.82	0.29
Reach-1	2330	99.00	74.30	78.21		78.34	0.000360	1.64	69.35	26.37	0.29
Reach-1	2330	21.40	74.30	76.18		76.22	0.000384	0.93	23.13	17.41	0.25
Reach-1	2330	490.00	74.30	83.12		83.43	0.000292	2.70	443.17	106.43	0.30
Reach-1	2394.2	22.20	74.71	76.26		76.27	0.000162	0.57	39.06	35.60	0.17
Reach-1	2394.2	46.30	74.71	77.08		77.10	0.000192	0.61	76.00	72.44	0.19
Reach-1	2394.2	60.30	74.71	77.48		77.50	0.000117	0.57	105.95	76.41	0.15
Reach-1	2394.2	69.60	74.71	77.71		77.73	0.000095	0.56	123.62	77.53	0.14
Reach-1	2394.2	78.60	74.71	77.92		77.93	0.000081	0.56	139.83	78.40	0.13
Reach-1	2394.2	90.00	74.71	78.17		78.19	0.000070	0.56	159.67	79.39	0.13
Reach-1	2394.2	99.00	74.71	78.37		78.39	0.000062	0.56	175.75	80.16	0.12
Reach-1	2394.2	21.40	74.71	76.23		76.24	0.000162	0.56	38.08	35.37	0.17
Reach-1	2394.2	490.00	74.71	83.50		83.52	0.000012	0.54	950.22	182.07	0.06
Reach-1	2394.25	Bridge									
Reach-1	2394.3	22.20	74.71	76.38	75.36	76.39	0.000121	0.51	43.56	37.44	0.15
Reach-1	2394.3	46.30	74.71	77.26	75.64	77.28	0.000114	0.52	89.70	73.89	0.15
Reach-1	2394.3	60.30	74.71	77.71	75.77	77.72	0.000072	0.49	123.38	77.52	0.12
Reach-1	2394.3	69.60	74.71	77.97	75.84	77.98	0.000059	0.48	143.63	78.60	0.11
Reach-1	2394.3	78.60	74.71	78.20	75.92	78.22	0.000050	0.48	162.53	79.53	0.11
Reach-1	2394.3	90.00	74.71	78.50	76.00	78.51	0.000043	0.49	185.96	80.65	0.10
Reach-1	2394.3	99.00	74.71	78.59	76.06	78.60	0.000046	0.51	193.44	81.00	0.11
Reach-1	2394.3	21.40	74.71	76.35	75.35	76.36	0.000121	0.50	42.42	36.87	0.15
Reach-1	2394.3	490.00	74.71	83.65	77.70	83.67	0.000011	0.52	977.59	182.15	0.06
Reach-1	2470	22.30	75.26	76.36		76.57	0.004076	2.00	11.25	17.67	0.76
Reach-1	2470	47.10	75.26	77.25		77.41	0.001121	1.79	38.41	44.78	0.45
Reach-1	2470	60.90	75.26	77.69		77.83	0.000771	1.74	61.12	58.43	0.39
Reach-1	2470	70.00	75.26	77.95		78.09	0.000651	1.73	77.21	66.06	0.37
Reach-1	2470	78.60	75.26	78.19		78.32	0.000559	1.72	93.36	67.83	0.34
Reach-1	2470	89.60	75.26	78.48		78.61	0.000474	1.70	113.25	68.18	0.32
Reach-1	2470	97.90	75.26	78.57		78.71	0.000501	1.79	119.46	68.29	0.33
Reach-1	2470	20.90	75.26	76.33		76.53	0.004105	1.95	10.74	16.99	0.75
Reach-1	2470	486.00	75.26	83.62		83.79	0.000217	2.30	731.77	135.87	0.26

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	2525	22.30	75.80	76.82	76.82	77.08	0.004840	2 47	20 69	50 79	0.85
Reach-1	2525	47.10	75.80	77.27		77.59	0.003794	2.91	44.55	53.38	0.81
Reach-1	2525	60.90	75.80	77.71		77.94	0.002079	2.61	68.31	55.80	0.63
Reach-1	2525	70.00	75.80	77.96		78.18	0.001635	2.53	82.71	57.20	0.57
Reach-1	2525	78.60	75.80	78.20		78.40	0.001358	2.48	96.26	58.48	0.53
Reach-1	2525	89.60	75.80	78.49		78.68	0.001123	2.45	113.31	60.05	0.49
Reach-1	2525	97.90	75.80	78.58		78.79	0.001177	2.56	118.74	60.54	0.51
Reach-1	2525	20.90	75.80	76.79	76.79	77.05	0.004818	2.42	19.40	50.65	0.85
Reach-1	2525	486.00	75.80	83.65		83.80	0.000314	2.72	843.50	170.00	0.31
Reach-1	2610	22.30	76.30	77.32	77.32	77.61	0.005026	2.53	18.40	43.17	0.87
Reach-1	2610	47.10	76.30	77.69	77.69	78.14	0.005343	3.31	35.01	45.20	0.95
Reach-1	2610	60.90	76.30	77.87	77.87	78.38	0.005337	3.62	43.00	45.98	0.97
Reach-1	2610	70.00	76.30	77.99	77.96	78.52	0.005189	3.76	48.43	46.51	0.97
Reach-1	2610	78.60	76.30	78.21		78.68	0.003926	3.58	58.91	48.32	0.86
Reach-1	2610	89.60	76.30	78.49		78.90	0.002929	3.41	72.71	50.68	0.76
Reach-1	2610	97.90	76.30	78.57		79.02	0.002994	3.55	77.19	51.93	0.78
Reach-1	2610	20.90	76.30	77.29	77.29	77.57	0.005017	2.47	17.23	42.99	0.86
Reach-1	2610	486.00	76.30	83.72		83.83	0.000286	2.49	1023.54	236.60	0.30
Reach-1	2692	22.30	76.50	77.73		77.86	0.001866	1.78	34.88	64.04	0.55
Reach-1	2692	47.10	76.50	78.23		78.39	0.001713	2.20	67.26	66.73	0.56
Reach-1	2692	60.90	76.50	78.45		78.63	0.001680	2.38	82.29	67.94	0.57
Reach-1	2692	70.00	76.50	78.58		78.78	0.001671	2.49	91.39	68.66	0.57
Reach-1	2692	78.60	76.50	78.70		78.91	0.001683	2.60	99.22	69.28	0.58
Reach-1	2692	89.60	76.50	78.88		79.10	0.001568	2.65	111.94	70.26	0.57
Reach-1	2692	97.90	76.50	78.99		79.22	0.001550	2.72	119.80	70.87	0.57
Reach-1	2692	20.90	76.50	77.70		77.82	0.001880	1.75	32.72	63.86	0.55
Reach-1	2692	486.00	76.50	83.76		83.85	0.000265	2.37	1095.39	256.29	0.28
Reach-1	2767.2	22.30	76.60	77.87	77.15	77.92	0.000165	1.00	22.19	65.28	0.28
Reach-1	2767.2	47.10	76.60	78.31	77.50	78.44	0.000271	1.57	29.96	68.19	0.38
Reach-1	2767.2	60.90	76.60	78.50	77.67	78.67	0.000322	1.83	33.20	68.75	0.43
Reach-1	2767.2	70.00	76.60	78.61	77.77	78.81	0.000351	1.99	35.18	69.09	0.45
Reach-1	2767.2	78.60	76.60	78.72	77.87	78.95	0.000369	2.12	37.14	69.43	0.46
Reach-1	2767.2	89.60	76.60	78.90	77.98	79.15	0.000367	2.23	40.25	69.97	0.47
Reach-1	2767.2	97.90	76.60	79.01	78.07	79.28	0.000376	2.32	42.16	70.92	0.48
Reach-1	2767.2	20.90	76.60	77.84	77.12	77.88	0.000158	0.97	21.63	63.67	0.28
Reach-1	2767.2	486.00	76.60	83.88	80.75	83.90	0.000012	0.86	871.84	200.75	0.10
Reach-1	2767.25	Bridge									
Reach-1	2767.3	22.30	76.85	78.05	77.40	78.10	0.000200	1.06	20.96	66.93	0.31
Reach-1	2767.3	47.10	76.85	78.70	77.75	78.80	0.000211	1.46	32.30	69.05	0.34
Reach-1	2767.3	60.90	76.85	79.01	77.92	79.14	0.000210	1.61	37.77	70.69	0.35
Reach-1	2767.3	70.00	76.85	79.13	78.02	79.29	0.000229	1.75	39.99	71.83	0.37
Reach-1	2767.3	78.60	76.85	79.31	78.12	79.48	0.000227	1.83	42.98	73.37	0.37
Reach-1	2767.3	89.60	76.85	79.52	78.23	79.71	0.000224	1.92	46.69	75.28	0.38
Reach-1	2767.3	97.90	76.85	79.68	78.32	79.88	0.000219	1.98	49.54	76.75	0.37
Reach-1	2767.3	20.90	76.85	78.00	77.37	78.06	0.000199	1.03	20.21	66.79	0.31
Reach-1	2767.3	486.00	76.85	84.64	80.75	84.65	0.000007	0.72	1013.49	203.63	0.08
Reach-1	2835.2	22.30	77.00	77.94	77.90	78.34	0.006747	2.80	7.95	8.89	0.95
Reach-1	2835.2	47.10	77.00	78.48	78.47	79.16	0.007057	3.67	12.84	9.39	1.00
Reach-1	2835.2	60.90	77.00	78.74	78.74	79.54	0.006907	3.96	15.39	9.64	1.00
Reach-1	2835.2	70.00	77.00	78.91	78.91	79.77	0.006829	4.12	17.00	9.80	1.00
Reach-1	2835.2	78.60	77.00	79.05	79.05	79.98	0.006848	4.27	18.39	9.93	1.00
Reach-1	2835.2	89.60	77.00	79.23	79.23	80.23	0.006775	4.43	20.21	10.10	1.00
Reach-1	2835.2	97.90	77.00	79.36	79.36	80.41	0.006751	4.55	21.53	10.22	1.00
Reach-1	2835.2	20.90	77.00	77.90	77.87	78.29	0.006708	2.74	7 64	8.85	0.94
Reach-1	2835.2	486.00	77.00	84.60	82.57	84.70	0.000154	1.41	351.03	117.17	0.17
Reach-1	2835.3	22.30	77.00	78.06	77.91	78.37	0.004608	2.48	9.01	9.00	0.79
Reach-1	2835.3	47.10	77.00	78.77	78.48	79.23	0.003957	3.02	15.62	9.66	0.76
Reach-1	2835.3	60.90	77.00	79.08	78.74	79.62	0.003924	3.26	18.69	9.96	0.76
Reach-1	2835.3	70.00	77.00	79.27	78.91	79.86	0.003910	3.40	20.61	10.14	0.76
Reach-1	2835.3	78.60	77.00	79.45	79.06	80.08	0.003862	3.50	22.44	10.31	0.76
Reach-1	2835.3	89.60	77.00	79.66	79.23	80.33	0.003871	3.64	24.59	10.50	0.76
Reach-1	2835.3	97.90	77.00	79.81	79.36	80.52	0.003857	3.74	26.21	10.64	0.76
Reach-1	2835.3	20.90	77.00	78.01	77.87	78.31	0.004670	2.43	8.59	8.95	0.79
Reach-1	2835.3	486.00	77.00	84.60	82.58	84.70	0.000154	1.41	351.05	117.17	0.17

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Cnt W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	2835.35	Bridge									
Reach-1	2835.4	22.30	77.00	78.30	77.90	78.50	0.002386	1.99	11.19	9.22	0.58
Reach-1	2835.4	47.10	77.00	79.01	78.47	79.36	0.002609	2.61	18.02	9.90	0.62
Reach-1	2835.4	60.90	77.00	79.34	78.74	79.75	0.002695	2.86	21.29	10.20	0.63
Reach-1	2835.4	70.00	77.00	79.54	78.90	80.00	0.002732	3.00	23.36	10.39	0.64
Reach-1	2835.4	78.60	77.00	79.72	79.05	80.21	0.002769	3.12	25.23	10.56	0.64
Reach-1	2835.4	89.60	77.00	79.94	79.23	80.47	0.002807	3.25	27.55	10.76	0.65
Reach-1	2835.4	97.90	77.00	80.09	79.35	80.66	0.002832	3.35	29.25	10.91	0.65
Reach-1	2835.4	20.90	77.00	78.25	77.87	78.44	0.002362	1.94	10.76	9.18	0.57
Reach-1	2835.4	486.00	77.00	84.75	82.57	84.84	0.000133	1.32	368.99	118.89	0.16
Reach-1	2835.5	22.30	77.00	78.30		78.50	0.002372	1.99	11.22	9.23	0.58
Reach-1	2835.5	47.10	77.00	79.01		79.36	0.002598	2.61	18.05	9.90	0.62
Reach-1	2835.5	60.90	77.00	79.34		79.76	0.002685	2.86	21.32	10.20	0.63
Reach-1	2835.5	70.00	77.00	79.54		80.00	0.002723	2.99	23.39	10.39	0.64
Reach-1	2835.5	78.60	77.00	79.72		80.21	0.002760	3.11	25.26	10.56	0.64
Reach-1	2835.5	89.60	77.00	79.94		80.48	0.002798	3.25	27.58	10.77	0.65
Reach-1	2835.5	97.90	77.00	80.09		80.66	0.002824	3.34	29.28	10.91	0.65
Reach-1	2835.5	20.90	77.00	78.25		78.44	0.002348	1.94	10.78	9.18	0.57
Reach-1	2835.5	486.00	77.00	84.75		84.84	0.000133	1.32	369.00	118.89	0.16
Reach-1	3122	22.30	77.30	78.58		78.72	0.001796	1.81	25.09	45.17	0.54
Reach-1	3122	47.10	77.30	79.46		79.56	0.000747	1.71	65.42	46.92	0.38
Reach-1	3122	60.90	77.30	79.86		79.96	0.000613	1.75	84.40	47.72	0.36
Reach-1	3122	70.00	77.30	80.11		80.21	0.000559	1.78	96.17	48.17	0.35
Reach-1	3122	78.60	77.30	80.33		80.43	0.000522	1.81	106.77	48.52	0.34
Reach-1	3122	89.60	77.30	80.59		80.70	0.000486	1.86	119.77	48.95	0.33
Reach-1	3122	97.90	77.30	80.79		80.89	0.000465	1.89	129.20	49.26	0.33
Reach-1	3122	20.90	77.30	78.52		78.67	0.001998	1.84	22.37	45.04	0.57
Reach-1	3122	486.00	77.30	84.76		84.87	0.000291	2.52	818.33	235.02	0.30
Reach-1	3171	22.30	77.60	78.64		78.88	0.004239	2.36	14.90	30.93	0.80
Reach-1	3171	47.10	77.60	79.48		79.62	0.001273	2.01	41.69	33.20	0.49
Reach-1	3171	60.90	77.60	79.87		80.01	0.000964	2.01	55.03	34.27	0.44
Reach-1	3171	70.00	77.60	80.12		80.25	0.000846	2.03	63.44	34.93	0.42
Reach-1	3171	78.60	77.60	80.33		80.47	0.000768	2.05	71.10	35.52	0.41
Reach-1	3171	89.60	77.60	80.60		80.74	0.000695	2.08	80.62	36.24	0.39
Reach-1	3171	97.90	77.60	80.79		80.93	0.000653	2.11	87.59	36.76	0.39
Reach-1	3171	20.90	77.60	78.59		78.85	0.004776	2.41	13.34	30.79	0.84
Reach-1	3171	486.00	77.60	84.78		84.89	0.000275	2.39	656.78	217.74	0.29
Reach-1	3210	22.00	78.00	79.07	79.07	79.34	0.004712	2.51	14.63	30.85	0.84
Reach-1	3210	46.90	78.00	79.43	79.43	79.82	0.005210	3.29	25.65	31.65	0.94
Reach-1	3210	59.70	78.00	79.85		80.12	0.002599	2.82	39.19	32.61	0.70
Reach-1	3210	67.80	78.00	80.10		80.34	0.001918	2.66	47.61	33.19	0.61
Reach-1	3210	75.30	78.00	80.33		80.54	0.001547	2.57	55.12	33.70	0.56
Reach-1	3210	84.80	78.00	80.60		80.80	0.001250	2.50	64.34	34.32	0.51
Reach-1	3210	91.80	78.00	80.79		80.98	0.001096	2.47	71.05	34.76	0.49
Reach-1	3210	20.80	78.00	79.06	79.06	79.31	0.004577	2.44	14.10	30.81	0.83
Reach-1	3210	492.00	78.00	84.81		84.90	0.000314	2.45	642.20	199.04	0.30
Reach-1	3269	22.00	78.10	79.39		79.47	0.001047	1.46	26.03	31.98	0.42
Reach-1	3269	46.90	78.10	79.84		79.99	0.001367	2.06	40.69	32.98	0.51
Reach-1	3269	59.70	78.10	80.06		80.24	0.001374	2.24	48.03	33.47	0.52
Reach-1	3269	67.80	78.10	80.26		80.43	0.001218	2.26	54.65	33.91	0.50
Reach-1	3269	75.30	78.10	80.45		80.62	0.001079	2.25	61.21	34.34	0.48
Reach-1	3269	84.80	78.10	80.70		80.86	0.000936	2.25	69.71	34.88	0.45
Reach-1	3269	91.80	78.10	80.88		81.04	0.000849	2.24	76.07	35.29	0.44
Reach-1	3269	20.80	78.10	79.36		79.44	0.001031	1.42	25.12	31.91	0.42
Reach-1	3269	492.00	78.10	84.82		84.92	0.000306	2.45	612.06	180.79	0.30
Reach-1	3315	22.00	78.03	79.44		79.53	0.001218	1.45	21.20	27.27	0.45
Reach-1	3315	46.90	78.03	79.89		80.06	0.001478	2.02	34.11	29.01	0.52
Reach-1	3315	59.70	78.03	80.11		80.31	0.001471	2.20	40.52	29.77	0.53
Reach-1	3315	67.80	78.03	80.30		80.50	0.001307	2.22	46.17	30.38	0.51
Reach-1	3315	75.30	78.03	80.49		80.68	0.001157	2.22	51.86	30.97	0.49
Reach-1	3315	84.80	78.03	80.72		80.92	0.000997	2.21	59.34	31.74	0.46
Reach-1	3315	91.80	78.03	80.90		81.09	0.000900	2.21	65.03	32.31	0.44
Reach-1	3315	20.80	78.03	79.41		79.50	0.001206	1.42	20.41	27.16	0.44
Reach-1	3315	492.00	78.03	84.77		84.97	0.000424	2.81	449.79	129.60	0.35

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	3415	22.00	78.30	79.52		79.74	0.002685	2.13	22.13	83.70	0.66
Reach-1	3415	46.90	78.30	80.04		80.24	0.001952	2.36	66.30	88.22	0.60
Reach-1	3415	59.70	78.30	80.27		80.47	0.001694	2.41	87.05	90.05	0.57
Reach-1	3415	67.80	78.30	80.46		80.63	0.001410	2.34	104.13	91.53	0.53
Reach-1	3415	75.30	78.30	80.64		80.80	0.001191	2.28	120.92	92.96	0.49
Reach-1	3415	84.80	78.30	80.87		81.02	0.000978	2.21	142.89	94.80	0.45
Reach-1	3415	91.80	78.30	81.05		81.18	0.000855	2.17	159.53	96.13	0.43
Reach-1	3415	20.80	78.30	79.50		79.71	0.002604	2.07	20.53	83.53	0.65
Reach-1	3415	492.00	78.30	84.82		85.01	0.000539	3.13	732.45	168.70	0.40
Reach-1	3500	22.00	78.55	79.82		79.89	0.001150	1.43	53.66	89.61	0.43
Reach-1	3500	46.90	78.55	80.28		80.38	0.001182	1.83	95.23	92.39	0.47
Reach-1	3500	59.70	78.55	80.49		80.59	0.001156	1.96	114.25	93.61	0.47
Reach-1	3500	67.80	78.55	80.64		80.74	0.001067	1.99	128.61	94.53	0.46
Reach-1	3500	75.30	78.55	80.79		80.90	0.000968	2.00	143.23	95.45	0.44
Reach-1	3500	84.80	78.55	81.00		81.10	0.000845	1.99	163.06	96.69	0.42
Reach-1	3500	91.80	78.55	81.16		81.25	0.000763	1.97	178.44	97.64	0.40
Reach-1	3500	20.80	78.55	79.80		79.86	0.001160	1.41	51.02	89.43	0.43
Reach-1	3500	492.00	78.55	84.89		85.06	0.000522	3.03	741.76	162.72	0.39
Reach-1	3590	22.00	79.05	80.01	80.01	80.30	0.006367	2.62	17.75	38.99	0.95
Reach-1	3590	46.90	79.05	80.40	80.40	80.84	0.006019	3.36	35.01	48.02	0.99
Reach-1	3590	59.70	79.05	80.57	80.57	81.06	0.005925	3.64	43.13	51.03	1.01
Reach-1	3590	67.80	79.05	80.66	80.66	81.19	0.005836	3.79	48.16	52.17	1.01
Reach-1	3590	75.30	79.05	80.75	80.75	81.31	0.005803	3.92	52.54	53.15	1.02
Reach-1	3590	84.80	79.05	80.84	80.84	81.44	0.005799	4.09	57.79	54.30	1.03
Reach-1	3590	91.80	79.05	80.96	80.91	81.54	0.005209	4.06	64.22	55.68	0.99
Reach-1	3590	20.80	79.05	79.98	79.98	80.26	0.006339	2.57	16.95	33.76	0.95
Reach-1	3590	492.00	79.05	84.84		85.17	0.001020	3.94	560.34	149.36	0.53
Reach-1	3660	22.00	79.30	80.41		80.62	0.003408	2.22	21.14	41.14	0.73
Reach-1	3660	46.90	79.30	80.83		81.17	0.003687	2.95	38.98	43.38	0.80
Reach-1	3660	59.70	79.30	80.99		81.40	0.003872	3.26	46.19	44.25	0.84
Reach-1	3660	67.80	79.30	81.08		81.54	0.004038	3.45	50.12	44.71	0.86
Reach-1	3660	75.30	79.30	81.16		81.65	0.004190	3.63	53.54	45.12	0.89
Reach-1	3660	84.80	79.30	81.25		81.80	0.004366	3.83	57.66	45.60	0.91
Reach-1	3660	91.80	79.30	81.29	81.22	81.90	0.004694	4.04	59.57	45.82	0.95
Reach-1	3660	20.80	79.30	80.38		80.59	0.003410	2.18	20.04	41.00	0.72
Reach-1	3660	492.00	79.30	84.92		85.24	0.001063	3.97	623.93	208.59	0.54
Reach-1	3726	22.00	79.50	80.68		80.80	0.002073	1.81	37.72	82.54	0.57
Reach-1	3726	46.90	79.50	81.21		81.34	0.001450	2.01	83.38	87.38	0.51
Reach-1	3726	59.70	79.50	81.44		81.57	0.001331	2.11	103.36	89.41	0.50
Reach-1	3726	67.80	79.50	81.57		81.71	0.001278	2.17	115.27	90.60	0.50
Reach-1	3726	75.30	79.50	81.69		81.83	0.001237	2.22	125.95	91.66	0.50
Reach-1	3726	84.80	79.50	81.83		81.97	0.001194	2.28	139.09	92.94	0.49
Reach-1	3726	91.80	79.50	81.93		82.08	0.001165	2.32	148.59	93.85	0.49
Reach-1	3726	20.80	79.50	80.65		80.77	0.002141	1.81	35.12	82.25	0.58
Reach-1	3726	492.00	79.50	85.14		85.31	0.000692	3.22	774.03	219.00	0.44
Reach-1	3790	22.00	79.70	80.80		80.97	0.002872	2.03	33.50	92.42	0.67
Reach-1	3790	46.90	79.70	81.31		81.45	0.001798	2.14	84.49	107.06	0.57
Reach-1	3790	59.70	79.70	81.53		81.66	0.001547	2.18	108.67	111.18	0.54
Reach-1	3790	67.80	79.70	81.66		81.79	0.001438	2.21	123.44	113.95	0.52
Reach-1	3790	75.30	79.70	81.78		81.91	0.001352	2.23	137.03	116.45	0.51
Reach-1	3790	84.80	79.70	81.92		82.05	0.001263	2.27	153.96	119.49	0.50
Reach-1	3790	91.80	79.70	82.02		82.16	0.001204	2.29	166.38	121.34	0.50
Reach-1	3790	20.80	79.70	80.78		80.95	0.002938	2.02	31.04	91.19	0.67
Reach-1	3790	492.00	79.70	85.18		85.36	0.000756	3.30	729.20	201.50	0.46
Reach-1	3865	22.00	80.00	81.06		81.17	0.002309	1.77	45.35	101.17	0.59
Reach-1	3865	46.90	80.00	81.47		81.59	0.001979	2.10	87.55	106.84	0.58
Reach-1	3865	59.70	80.00	81.67		81.79	0.001762	2.17	108.81	108.43	0.56
Reach-1	3865	67.80	80.00	81.79		81.91	0.001647	2.21	121.97	109.27	0.55
Reach-1	3865	75.30	80.00	81.90		82.02	0.001553	2.24	134.01	110.03	0.54
Reach-1	3865	84.80	80.00	82.03		82.16	0.001453	2.28	148.93	110.97	0.53
Reach-1	3865	91.80	80.00	82.13		82.25	0.001389	2.31	159.73	111.65	0.52
Reach-1	3865	20.80	80.00	81.04		81.15	0.002319	1.75	43.12	100.86	0.59
Reach-1	3865	492.00	80.00	85.21		85.44	0.000980	3.62	650.56	187.71	0.51
Reach-1	3935	22.00	80.30	81.26		81.34	0.002616	1.73	45.87	95.33	0.62
Reach-1	3935	46.90	80.30	81.62		81.75	0.002495	2.18	81.48	97.58	0.64

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	3935	59.70	80.30	81.80		81.93	0.002310	2.30	98.90	98.66	0.63
Reach-1	3935	67.80	80.30	81.91		82.05	0.002194	2.37	109.79	99.33	0.63
Reach-1	3935	75.30	80.30	82.01		82.15	0.002089	2.41	119.84	99.94	0.62
Reach-1	3935	84.80	80.30	82.14		82.28	0.001971	2.47	132.40	100.70	0.61
Reach-1	3935	91.80	80.30	82.23		82.37	0.001891	2.50	141.57	101.25	0.60
Reach-1	3935	20.80	80.30	81.23		81.32	0.002614	1.70	43.88	95.21	0.62
Reach-1	3935	492.00	80.30	85.23		85.55	0.001354	4.10	574.06	184.64	0.60
Reach-1	3990	22.00	80.50	81.40		81.50	0.003037	1.79	32.73	65.73	0.66
Reach-1	3990	46.90	80.50	81.76		81.89	0.002870	2.25	57.55	70.79	0.68
Reach-1	3990	59.70	80.50	81.93		82.07	0.002698	2.40	69.33	71.68	0.68
Reach-1	3990	67.80	80.50	82.03		82.18	0.002580	2.47	76.70	72.23	0.67
Reach-1	3990	75.30	80.50	82.12		82.28	0.002470	2.52	83.52	72.74	0.66
Reach-1	3990	84.80	80.50	82.24		82.40	0.002338	2.59	92.10	73.37	0.66
Reach-1	3990	91.80	80.50	82.33		82.49	0.002246	2.62	98.40	73.83	0.65
Reach-1	3990	20.80	80.50	81.38		81.47	0.003041	1.76	31.39	64.94	0.66
Reach-1	3990	492.00	80.50	85.29		85.63	0.001459	4.18	430.57	153.12	0.62
Reach-1	4040	22.00	80.47	81.53	81.53	81.84	0.005223	2.58	11.13	26.37	0.88
Reach-1	4040	46.90	80.47	81.96	81.96	82.39	0.004833	3.23	22.88	28.74	0.90
Reach-1	4040	59.70	80.47	82.11	82.11	82.62	0.004967	3.53	27.45	29.62	0.93
Reach-1	4040	67.80	80.47	82.21	82.21	82.75	0.004915	3.68	30.44	30.18	0.94
Reach-1	4040	75.30	80.47	82.30	82.30	82.86	0.004921	3.81	33.00	30.64	0.95
Reach-1	4040	84.80	80.47	82.40	82.40	83.00	0.004958	3.97	36.04	31.19	0.96
Reach-1	4040	91.80	80.47	82.46	82.46	83.10	0.005041	4.10	38.04	31.55	0.98
Reach-1	4040	20.80	80.47	81.51	81.49	81.81	0.005048	2.50	10.67	26.27	0.86
Reach-1	4040	492.00	80.47	85.18		85.98	0.002763	5.61	258.60	151.05	0.84
Reach-1	4075	22.00	80.65	81.77	81.77	82.02	0.004299	2.42	15.69	35.00	0.81
Reach-1	4075	46.90	80.65	82.35		82.56	0.002317	2.46	36.07	35.00	0.64
Reach-1	4075	59.70	80.65	82.58		82.80	0.002145	2.60	43.84	35.00	0.63
Reach-1	4075	67.80	80.65	82.70		82.93	0.002106	2.70	48.13	35.00	0.63
Reach-1	4075	75.30	80.65	82.81		83.05	0.002074	2.78	51.94	35.00	0.63
Reach-1	4075	84.80	80.65	82.94		83.20	0.002042	2.88	56.56	35.00	0.64
Reach-1	4075	91.80	80.65	83.03		83.30	0.002017	2.95	59.89	35.00	0.64
Reach-1	4075	20.80	80.65	81.75	81.75	81.99	0.004265	2.38	14.96	35.00	0.80
Reach-1	4075	492.00	80.65	84.45	84.45	86.71	0.009232	8.80	109.42	35.00	1.48
Reach-1	4105	22.00	80.80	81.89		82.17	0.004955	2.55	14.67	35.00	0.86
Reach-1	4105	46.90	80.80	82.41		82.66	0.003043	2.71	32.71	35.00	0.73
Reach-1	4105	59.70	80.80	82.63		82.89	0.002730	2.82	40.32	35.00	0.71
Reach-1	4105	67.80	80.80	82.75		83.02	0.002635	2.91	44.56	35.00	0.70
Reach-1	4105	75.30	80.80	82.86		83.14	0.002561	2.98	48.35	35.00	0.70
Reach-1	4105	84.80	80.80	82.99		83.29	0.002486	3.07	52.93	35.00	0.70
Reach-1	4105	91.80	80.80	83.08		83.39	0.002432	3.14	56.24	35.00	0.69
Reach-1	4105	20.80	80.80	81.87		82.14	0.004963	2.51	13.90	35.00	0.86
Reach-1	4105	492.00	80.80	84.60	84.60	86.86	0.009258	8.81	109.31	35.00	1.48
Reach-1	4140	Bridge									
Reach-1	4160	22.00	81.00	82.62	82.18	82.67	0.000676	1.26	34.73	40.80	0.34
Reach-1	4160	46.90	81.00	83.43	82.49	83.48	0.000456	1.40	67.64	40.80	0.30
Reach-1	4160	59.70	81.00	84.22	82.62	84.26	0.000225	1.21	100.23	40.80	0.22
Reach-1	4160	67.80	81.00	84.30	82.69	84.35	0.000264	1.33	103.36	40.80	0.24
Reach-1	4160	75.30	81.00	84.39	82.75	84.45	0.000292	1.43	107.11	40.80	0.26
Reach-1	4160	84.80	81.00	84.55	82.83	84.61	0.000310	1.52	113.56	40.80	0.27
Reach-1	4160	91.80	81.00	84.70	82.89	84.76	0.000311	1.57	119.45	40.80	0.27
Reach-1	4160	20.80	81.00	82.57	82.16	82.63	0.000701	1.25	32.88	40.80	0.34
Reach-1	4160	492.00	81.00	85.49	84.94	87.12	0.005651	7.66	174.58	100.17	1.18
Reach-1	4210	22.00	81.60	82.61	82.61	82.87	0.004793	2.45	14.00	30.58	0.85
Reach-1	4210	46.90	81.60	83.39		83.55	0.001517	2.13	40.34	36.00	0.53
Reach-1	4210	59.70	81.60	84.21		84.29	0.000501	1.60	70.70	38.14	0.33
Reach-1	4210	67.80	81.60	84.29		84.38	0.000577	1.75	73.54	38.34	0.35
Reach-1	4210	75.30	81.60	84.38		84.49	0.000623	1.86	77.02	38.57	0.37
Reach-1	4210	84.80	81.60	84.53		84.65	0.000635	1.96	83.10	38.99	0.37
Reach-1	4210	91.80	81.60	84.68		84.80	0.000615	1.99	88.75	39.36	0.37
Reach-1	4210	20.80	81.60	82.59	82.59	82.84	0.004776	2.40	13.33	30.40	0.84
Reach-1	4210	492.00	81.60	85.69	85.22	87.48	0.006163	7.70	148.09	88.26	1.24
Reach-1	4260	22.00	81.70	82.81	82.77	83.17	0.005234	2.66	9.36	14.94	0.88
Reach-1	4260	46.90	81.70	83.38		83.80	0.003876	3.08	23.29	30.53	0.82

HEC-RAS Plan: iadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	4260	59 70	81.70	84.20		84.37	0.000958	2.07	51.47	37.44	0.44
Reach-1	4260	67 80	81.70	84.28		84.47	0.001085	2.25	54.24	38.05	0.47
Reach-1	4260	75 30	81.70	84.37		84.57	0.001147	2.37	57.69	38.80	0.48
Reach-1	4260	84.80	81.70	84.53		84.74	0.001125	2.45	63.90	40.03	0.48
Reach-1	4260	91 80	81.70	84.67		84.88	0.001052	2.46	69.78	40.75	0.47
Reach-1	4260	20 80	81.70	82.79		83.12	0.005031	2.58	9.06	14.60	0.86
Reach-1	4260	492.00	81.70	86.75	86.75	87.74	0.002912	5.94	208.26	91.59	0.86
Reach-1	4275	22.00	81.70	83.14		83.27	0.001414	1.69	20.34	35.04	0.48
Reach-1	4275	46.90	81.70	83.76		83.91	0.001148	1.99	42.42	36.87	0.47
Reach-1	4275	59 70	81.70	84.28		84.39	0.000669	1.79	62.14	38.43	0.37
Reach-1	4275	67 80	81.70	84.37		84.50	0.000746	1.94	65.50	38.69	0.39
Reach-1	4275	75.30	81.70	84.47		84.61	0.000788	2.05	69.29	38.98	0.41
Reach-1	4275	84.80	81.70	84.62		84.77	0.000792	2.13	75.42	39.63	0.41
Reach-1	4275	91.80	81.70	84.76		84.91	0.000765	2.17	80.89	40.24	0.41
Reach-1	4275	20.80	81.70	83.09		83.22	0.001520	1.71	18.53	34.88	0.50
Reach-1	4275	492.00	81.70	86.77		87.81	0.002902	6.02	204.91	91.65	0.87
Reach-1	4279	Bridge									
Reach-1	4290	22.00	81.70	83.19	82.80	83.30	0.001215	1.61	21.90	35.17	0.45
Reach-1	4290	46.90	81.70	83.80	83.28	83.93	0.001055	1.94	43.81	36.98	0.45
Reach-1	4290	59.70	81.70	84.30	83.43	84.41	0.000646	1.77	62.93	38.49	0.37
Reach-1	4290	67 80	81.70	84.39	83.51	84.52	0.000718	1.92	66.43	38.76	0.39
Reach-1	4290	75.30	81.70	84.50	83.59	84.63	0.000752	2.01	70.48	39.07	0.40
Reach-1	4290	84.80	81.70	84.65	83.68	84.80	0.000756	2.10	76.71	39.77	0.40
Reach-1	4290	91 80	81.70	84.79	83.75	84.94	0.000732	2.14	82.22	40.38	0.40
Reach-1	4290	20 80	81.70	83.14	82.77	83.25	0.001282	1.61	20.21	35.03	0.46
Reach-1	4290	492.00	81.70	87.96	86.27	88.35	0.000939	3.96	316.83	95.20	0.51
Reach-1	4300	22.00	81.80	83.22		83.33	0.001266	1.59	24.11	40.07	0.46
Reach-1	4300	46 90	81.80	83.85		83.96	0.000919	1.79	51.35	45.33	0.42
Reach-1	4300	59 70	81.80	84.35		84.43	0.000546	1.61	74.48	47.83	0.34
Reach-1	4300	67 80	81.80	84.45		84.54	0.000592	1.73	79.27	48.29	0.35
Reach-1	4300	75 30	81.80	84.56		84.66	0.000609	1.81	84.64	48.80	0.36
Reach-1	4300	84.80	81.80	84.72		84.83	0.000599	1.87	92.73	49.56	0.36
Reach-1	4300	91.80	81.80	84.86		84.97	0.000573	1.89	99.71	50.20	0.36
Reach-1	4300	20.80	81.80	83.17		83.28	0.001356	1.61	22.17	39.53	0.47
Reach-1	4300	492.00	81.80	88.20		88.41	0.000590	3.20	393.17	103.53	0.41
Reach-1	4360.3	22.00	82.00	83.28		83.38	0.001113	1.40	15.72	12.65	0.40
Reach-1	4360.3	46 90	82.00	83.83		84.04	0.001622	2.06	22.78	12.94	0.50
Reach-1	4360.3	59.70	82.00	84.29		84.50	0.001307	2.08	28.76	13.17	0.45
Reach-1	4360.3	67.80	82.00	84.37		84.63	0.001514	2.27	29.82	13.21	0.48
Reach-1	4360.3	75.30	82.00	84.46		84.76	0.001659	2.43	31.04	13.26	0.51
Reach-1	4360.3	84.80	82.00	84.60		84.94	0.001769	2.58	32.91	13.33	0.52
Reach-1	4360.3	91.80	82.00	84.72		85.08	0.001793	2.65	34.58	13.40	0.53
Reach-1	4360.3	20 80	82.00	83.24		83.33	0.001096	1.37	15.24	12.63	0.40
Reach-1	4360.3	492.00	82.00	88.19		88.45	0.000509	2.32	217.89	76.04	0.30
Reach-1	4360.35	Bridge									
Reach-1	4360.4	22.00	82.00	83.32	82.69	83.41	0.000998	1.35	16.28	12.68	0.38
Reach-1	4360.4	46.90	82.00	83.90	83.15	84.10	0.001437	1.98	23.71	12.97	0.47
Reach-1	4360.4	59 70	82.00	84.34	83.35	84.55	0.001212	2.02	29.49	13.20	0.43
Reach-1	4360.4	67.80	82.00	84.43	83.47	84.68	0.001388	2.21	30.71	13.25	0.46
Reach-1	4360.4	75.30	82.00	84.53	83.57	84.81	0.001509	2.35	32.04	13.30	0.48
Reach-1	4360.4	84 80	82.00	84.68	83.69	85.00	0.001605	2.49	34.02	13.38	0.50
Reach-1	4360.4	91 80	82.00	84.81	83.79	85.14	0.001631	2.57	35.72	13.44	0.50
Reach-1	4360.4	20 80	82.00	83.28	82.67	83.37	0.000982	1.32	15.78	12.66	0.38
Reach-1	4360.4	492 00	82.00	88.23	87.02	88.48	0.000487	2.28	220.83	76.14	0.30
Reach-1	4438	22 00	82.30	83.51	83.51	83.80	0.004184	2.43	11.09	30.00	0.79
Reach-1	4438	46.90	82.30	83.91		84.29	0.004145	3.04	23.00	30.00	0.83
Reach-1	4438	59.70	82.30	84.40		84.62	0.001798	2.46	37.68	30.00	0.58
Reach-1	4438	67 80	82.30	84.51		84.75	0.001807	2.57	41.14	30.00	0.58
Reach-1	4438	75.30	82.30	84.66		84.90	0 001672	2.59	45.46	30.00	0.57
Reach-1	4438	84 80	82.30	84.86		85.09	0.001479	2.58	51.43	30.00	0.54
Reach-1	4438	91.80	82.30	85 01		85.24	0.001339	2.57	56.14	30.00	0.52
Reach-1	4438	20.80	82 30	83.36	83.36	83.77	0.007017	2.84	7.32	8.84	1.00
Reach-1	4438	492.00	82.30	88.22		88.55	0.000975	3 81	308.18	121.00	0.51

HEC-RAS Plan: jadp-rep River: RIVER 1 Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Cnt W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	4495	28.30	82.80	84.09	84.09	84.37	0.003864	2.52	19.77	42.28	.78
Reach-1	4495	46.80	82.80	84.33	84.33	84.68	0.004229	3.00	28.73	42.98	0.84
Reach-1	4495	58.70	82.80	84.46	84.46	84.85	0.004353	3.24	34.22	43.36	0.86
Reach-1	4495	67.00	82.80	84.54		84.95	0.004333	3.37	38.08	43.63	0.87
Reach-1	4495	75.20	82.80	84.70		85.07	0.003539	3.25	44.96	44.10	0.80
Reach-1	4495	86.10	82.80	84.90		85.23	0.002831	3.14	54.00	44.71	0.73
Reach-1	4495	94.60	82.80	85.06		85.36	0.002447	3.07	61.00	45.37	0.69
Reach-1	4495	20.70	82.80	83.95	83.95	84.21	0.004076	2.34	12.58	40.26	0.78
Reach-1	4495	484.00	82.80	88.33		88.61	0.000976	3.68	408.52	190.50	0.51
Reach-1	4530	28.30	83.00	84.23		84.53	0.004569	2.63	19.70	55.97	0.84
Reach-1	4530	46.80	83.00	84.62		84.81	0.002399	2.37	42.22	60.63	0.64
Reach-1	4530	58.70	83.00	84.79		84.97	0.002171	2.43	52.73	63.93	0.62
Reach-1	4530	67.00	83.00	84.89		85.08	0.002076	2.48	59.56	65.98	0.61
Reach-1	4530	75.20	83.00	84.99		85.18	0.002013	2.54	65.94	67.85	0.61
Reach-1	4530	86.10	83.00	85.15		85.32	0.001767	2.51	76.73	69.16	0.58
Reach-1	4530	94.60	83.00	85.28		85.45	0.001560	2.47	86.14	70.18	0.55
Reach-1	4530	20.70	83.00	84.17	84.17	84.38	0.003430	2.18	16.07	55.42	0.72
Reach-1	4530	484.00	83.00	88.52		88.65	0.000567	2.80	562.61	238.47	0.39
Reach-1	4590	28.30	83.20	84.48		84.80	0.004393	2.66	17.16	45.59	0.83
Reach-1	4590	46.80	83.20	84.77	84.77	85.09	0.003822	2.91	30.87	49.76	0.80
Reach-1	4590	58.70	83.20	84.88	84.88	85.25	0.004081	3.17	36.57	51.00	0.84
Reach-1	4590	67.00	83.20	84.96	84.96	85.35	0.004135	3.31	40.65	51.87	0.85
Reach-1	4590	75.20	83.20	85.03	85.03	85.44	0.004212	3.44	44.35	52.65	0.87
Reach-1	4590	86.10	83.20	85.12		85.56	0.004232	3.58	49.37	53.69	0.88
Reach-1	4590	94.60	83.20	85.26		85.65	0.003585	3.47	56.76	55.18	0.82
Reach-1	4590	20.70	83.20	84.35	84.34	84.62	0.004151	2.37	11.79	36.96	0.79
Reach-1	4590	484.00	83.20	88.57		88.69	0.000563	2.73	625.85	305.72	0.38
Reach-1	4635	28.30	83.40	84.71		84.99	0.003734	2.50	23.42	54.05	0.77
Reach-1	4635	46.80	83.40	84.89		85.33	0.005221	3.27	33.18	55.78	0.93
Reach-1	4635	58.70	83.40	85.08	85.08	85.50	0.004455	3.32	43.93	57.63	0.88
Reach-1	4635	67.00	83.40	85.16	85.16	85.61	0.004534	3.48	48.88	58.46	0.89
Reach-1	4635	75.20	83.40	85.24	85.24	85.72	0.004641	3.63	53.36	59.20	0.91
Reach-1	4635	86.10	83.40	85.33	85.33	85.85	0.004811	3.84	58.82	60.09	0.94
Reach-1	4635	94.60	83.40	85.41	85.41	85.95	0.004853	3.96	63.28	60.81	0.95
Reach-1	4635	20.70	83.40	84.54		84.81	0.004156	2.36	14.49	52.41	0.78
Reach-1	4635	484.00	83.40	88.42		88.81	0.001594	4.39	596.37	327.19	0.64
Reach-1	4705	28.30	83.20	85.00		85.13	0.001017	1.70	36.62	46.56	0.43
Reach-1	4705	46.80	83.20	85.31		85.52	0.001357	2.21	52.00	51.53	0.51
Reach-1	4705	58.70	83.20	85.43		85.69	0.001701	2.57	57.87	53.30	0.58
Reach-1	4705	67.00	83.20	85.51		85.82	0.001885	2.78	62.36	54.58	0.61
Reach-1	4705	75.20	83.20	85.59		85.94	0.002055	2.97	66.61	55.50	0.64
Reach-1	4705	86.10	83.20	85.68		86.09	0.002266	3.21	72.00	56.66	0.68
Reach-1	4705	94.60	83.20	85.75		86.19	0.002451	3.40	75.61	57.41	0.71
Reach-1	4705	20.70	83.20	84.85		84.94	0.000809	1.42	29.77	44.17	0.38
Reach-1	4705	484.00	83.20	87.57	87.57	89.71	0.006518	8.13	193.05	70.32	1.27
Reach-1	4770	28.30	83.70	84.98	84.98	85.37	0.005090	2.84	16.64	38.87	0.88
Reach-1	4770	46.80	83.70	85.35	85.35	85.77	0.004170	3.13	36.57	70.88	0.84
Reach-1	4770	58.70	83.70	85.55	85.55	85.96	0.003664	3.20	52.55	84.77	0.81
Reach-1	4770	67.00	83.70	85.64	85.64	86.08	0.003734	3.35	60.06	85.27	0.82
Reach-1	4770	75.20	83.70	85.64		86.19	0.004594	3.73	60.81	85.31	0.91
Reach-1	4770	86.10	83.70	85.81		86.31	0.003989	3.69	74.57	86.21	0.86
Reach-1	4770	94.60	83.70	85.91		86.40	0.003748	3.71	83.73	86.81	0.84
Reach-1	4770	20.70	83.70	84.77	84.76	85.13	0.005732	2.68	9.91	25.61	0.91
Reach-1	4770	484.00	83.70	89.63		90.04	0.001176	4.21	573.04	211.01	0.56
Reach-1	4832	28.30	84.10	85.36		85.67	0.004527	2.67	21.95	39.68	0.83
Reach-1	4832	46.80	84.10	85.61		86.07	0.005329	3.31	33.29	53.71	0.93
Reach-1	4832	58.70	84.10	85.81	85.81	86.28	0.004810	3.45	45.41	73.30	0.91
Reach-1	4832	67.00	84.10	85.92	85.92	86.41	0.004561	3.53	54.71	85.34	0.89
Reach-1	4832	75.20	84.10	86.04	86.04	86.52	0.004233	3.57	65.37	94.24	0.87
Reach-1	4832	86.10	84.10	86.15	86.15	86.65	0.004246	3.72	75.52	96.97	0.88
Reach-1	4832	94.60	84.10	86.22	86.22	86.74	0.004309	3.85	82.58	98.82	0.89
Reach-1	4832	20.70	84.10	85.17		85.47	0.004933	2.51	14.83	36.87	0.85
Reach-1	4832	484.00	84.10	89.79		90.12	0.001102	3.95	616.32	215.00	0.54
Reach-1	4864	28.30	84.30	85.68		85.77	0.001307	1.63	38.46	67.59	0.47
Reach-1	4864	46.80	84.30	86.09		86.17	0.000879	1.62	70.99	87.29	0.40

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	4864	58.70	84.30	86.30		86.37	0.000772	1.64	89.59	92.45	0.39
Reach-1	4864	67.00	84.30	86.43		86.49	0.000734	1.67	101.33	95.57	0.38
Reach-1	4864	75.20	84.30	86.53		86.60	0.000717	1.71	111.73	97.97	0.38
Reach-1	4864	86.10	84.30	86.66		86.74	0.000696	1.76	124.75	99.62	0.38
Reach-1	4864	94.60	84.30	86.76		86.83	0.000681	1.79	134.37	100.39	0.38
Reach-1	4864	20.70	84.30	85.47		85.57	0.001663	1.62	25.72	56.63	0.51
Reach-1	4864	484.00	84.30	90.08		90.16	0.000332	2.27	633.09	207.79	0.31
Reach-1	4959	28.30	84.80	86.23	86.23	86.45	0.002901	2.28	25.62	70.44	0.66
Reach-1	4959	46.80	84.80	86.42	86.42	86.68	0.003479	2.70	39.06	71.37	0.74
Reach-1	4959	58.70	84.80	86.52	86.52	86.80	0.003830	2.94	45.70	71.83	0.78
Reach-1	4959	67.00	84.80	86.57	86.57	86.87	0.004080	3.09	49.71	72.10	0.81
Reach-1	4959	75.20	84.80	86.63	86.63	86.94	0.004288	3.23	53.52	72.36	0.83
Reach-1	4959	86.10	84.80	86.65		87.03	0.005182	3.58	55.29	72.48	0.92
Reach-1	4959	94.60	84.80	86.77		87.09	0.004351	3.41	63.69	73.05	0.85
Reach-1	4959	20.70	84.80	85.99	85.99	86.30	0.004499	2.50	11.02	39.89	0.80
Reach-1	4959	484.00	84.80	90.07		90.27	0.000986	3.34	454.50	217.89	0.48
Reach-1	5006	28.30	85.20	86.47		86.55	0.001461	1.61	41.10	73.79	0.49
Reach-1	5006	46.80	85.20	86.70		86.79	0.001587	1.90	58.01	75.33	0.52
Reach-1	5006	58.70	85.20	86.81		86.92	0.001687	2.07	66.73	76.11	0.55
Reach-1	5006	67.00	85.20	86.88		87.00	0.001749	2.18	72.32	76.61	0.56
Reach-1	5006	75.20	85.20	86.95		87.08	0.001813	2.28	77.40	77.06	0.58
Reach-1	5006	86.10	85.20	87.06		87.19	0.001753	2.35	86.01	77.81	0.57
Reach-1	5006	94.60	85.20	87.08		87.23	0.002025	2.54	87.32	77.93	0.62
Reach-1	5006	20.70	85.20	86.37		86.44	0.001245	1.40	34.14	73.15	0.44
Reach-1	5006	484.00	85.20	90.04		90.37	0.001328	4.01	378.38	212.82	0.59
Reach-1	5021	Bridge									
Reach-1	5036	28.30	85.20	86.93	86.29	86.95	0.000275	0.88	75.54	76.89	0.22
Reach-1	5036	46.80	85.20	87.51	86.45	87.53	0.000187	0.90	121.76	80.87	0.19
Reach-1	5036	58.70	85.20	87.85	86.52	87.86	0.000161	0.92	149.23	83.14	0.19
Reach-1	5036	67.00	85.20	88.07	86.58	88.09	0.000148	0.93	167.80	84.65	0.18
Reach-1	5036	75.20	85.20	88.28	86.63	88.30	0.000138	0.94	185.72	86.07	0.18
Reach-1	5036	86.10	85.20	88.86	86.69	88.88	0.000088	0.85	237.20	90.04	0.14
Reach-1	5036	94.60	85.20	88.97	86.73	88.98	0.000094	0.90	246.69	90.75	0.15
Reach-1	5036	20.70	85.20	86.65	86.20	86.67	0.000371	0.90	54.39	75.00	0.25
Reach-1	5036	484.00	85.20	91.15	88.09	91.25	0.000368	2.43	618.61	221.02	0.32
Reach-1	5060	28.30	85.40	86.92		86.97	0.000727	1.30	50.34	71.52	0.36
Reach-1	5060	46.80	85.40	87.51		87.54	0.000362	1.17	94.24	77.34	0.27
Reach-1	5060	58.70	85.40	87.85		87.88	0.000282	1.15	120.75	80.65	0.24
Reach-1	5060	67.00	85.40	88.07		88.10	0.000246	1.14	138.86	82.84	0.23
Reach-1	5060	75.20	85.40	88.28		88.31	0.000220	1.14	156.48	84.92	0.22
Reach-1	5060	86.10	85.40	88.86		88.88	0.000128	0.99	207.86	90.69	0.17
Reach-1	5060	94.60	85.40	88.97		88.99	0.000136	1.04	217.43	91.73	0.18
Reach-1	5060	20.70	85.40	86.63		86.72	0.001326	1.50	30.18	68.68	0.46
Reach-1	5060	484.00	85.40	91.15		91.27	0.000499	2.77	555.85	213.85	0.37
Reach-1	5095	28.30	85.70	86.96		87.00	0.000530	0.95	34.27	78.28	0.29
Reach-1	5095	46.80	85.70	87.54		87.56	0.000099	0.55	89.24	120.55	0.14
Reach-1	5095	58.70	85.70	87.87		87.89	0.000047	0.42	129.86	122.58	0.10
Reach-1	5095	67.00	85.70	88.10		88.11	0.000033	0.38	157.07	123.92	0.08
Reach-1	5095	75.20	85.70	88.31		88.31	0.000025	0.36	183.15	125.19	0.07
Reach-1	5095	86.10	85.70	88.88		88.89	0.000011	0.27	256.43	128.70	0.05
Reach-1	5095	94.60	85.70	88.99		89.00	0.000011	0.28	270.22	129.35	0.05
Reach-1	5095	20.70	85.70	86.71	86.71	86.82	0.002341	1.68	16.17	68.13	0.59
Reach-1	5095	484.00	85.70	91.27		91.31	0.000028	0.64	628.78	198.58	0.09
Reach-1	5110	Bridge									
Reach-1	5125	28.30	85.70	87.43	86.77	87.43	0.000051	0.37	76.55	102.70	0.10
Reach-1	5125	46.80	85.70	87.98	86.86	87.98	0.000022	0.30	142.18	123.19	0.07
Reach-1	5125	58.70	85.70	88.29	86.92	88.30	0.000016	0.28	181.27	125.10	0.06
Reach-1	5125	67.00	85.70	88.50	86.96	88.50	0.000013	0.27	207.43	126.37	0.05
Reach-1	5125	75.20	85.70	88.70	86.99	88.70	0.000012	0.27	232.58	127.57	0.05
Reach-1	5125	86.10	85.70	89.39	87.04	89.39	0.000005	0.21	322.29	131.77	0.04
Reach-1	5125	94.60	85.70	89.52	87.06	89.52	0.000006	0.22	339.29	132.55	0.04
Reach-1	5125	20.70	85.70	87.17	86.71	87.18	0.000087	0.43	51.77	90.10	0.12
Reach-1	5125	484.00	85.70	92.42	88.00	92.44	0.000011	0.45	855.18	207.45	0.06

HEC-RAS Plan: 1adp-rep River: RIVER-1 Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Cnt W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5172	28.30	85.90	87.40		87.47	0.000875	1.42	49.40	89.03	[illegible]
Reach-1	5172	46.80	85.90	87.96		88.00	0.000375	1.17	100.42	92.89	0.27
Reach-1	5172	58.70	85.90	88.28		88.31	0.000281	1.12	130.16	95.06	0.24
Reach-1	5172	67.00	85.90	88.49		88.52	0.000242	1.11	150.15	96.49	0.23
Reach-1	5172	75.20	85.90	88.69		88.71	0.000214	1.10	169.44	97.85	0.22
Reach-1	5172	86.10	85.90	89.38		89.40	0.000101	0.88	239.11	102.62	0.15
Reach-1	5172	94.60	85.90	89.51		89.53	0.000104	0.92	252.34	103.50	0.16
Reach-1	5172	20.70	85.90	87.12		87.25	0.001899	1.78	24.21	87.03	0.55
Reach-1	5172	484.00	85.90	92.40		92.46	0.000223	2.01	673.22	175.91	0.25
Reach-1	5200	28.30	85.95	87.44		87.49	0.000602	1.05	40.74	63.32	0.32
Reach-1	5200	46.80	85.95	87.97		88.01	0.000333	1.01	81.45	80.67	0.25
Reach-1	5200	58.70	85.95	88.28		88.32	0.000254	0.99	107.15	83.43	0.23
Reach-1	5200	67.00	85.95	88.49		88.52	0.000219	0.99	124.64	85.26	0.21
Reach-1	5200	75.20	85.95	88.69		88.72	0.000194	0.98	141.66	87.00	0.20
Reach-1	5200	86.10	85.95	89.38		89.40	0.000091	0.80	205.63	96.84	0.15
Reach-1	5200	94.60	85.95	89.51		89.53	0.000094	0.83	218.11	97.99	0.15
Reach-1	5200	20.70	85.95	87.24		87.29	0.000712	1.01	28.47	60.98	0.33
Reach-1	5200	484.00	85.95	92.39		92.47	0.000192	1.83	624.19	170.91	0.24
Reach-1	5214	28.30	86.00	87.44		87.50	0.000656	1.12	28.09	29.80	0.33
Reach-1	5214	46.80	86.00	87.96		88.03	0.000520	1.25	43.97	31.88	0.31
Reach-1	5214	58.70	86.00	88.26		88.35	0.000463	1.31	53.96	33.13	0.30
Reach-1	5214	67.00	86.00	88.47		88.55	0.000433	1.34	60.82	33.95	0.29
Reach-1	5214	75.20	86.00	88.66		88.75	0.000424	1.40	68.80	43.23	0.29
Reach-1	5214	86.10	86.00	89.36		89.42	0.000216	1.17	101.61	51.19	0.21
Reach-1	5214	94.60	86.00	89.49		89.56	0.000224	1.22	108.17	52.73	0.22
Reach-1	5214	20.70	86.00	87.25		87.30	0.000641	0.99	22.48	29.02	0.32
Reach-1	5214	484.00	86.00	92.32		92.55	0.000412	2.53	393.26	142.00	0.33
Reach-1	5225	28.30	86.17	87.43		87.54	0.001267	1.50	18.92	15.06	0.43
Reach-1	5225	46.80	86.17	87.92		88.08	0.001228	1.77	26.40	15.06	0.43
Reach-1	5225	58.70	86.17	88.22		88.41	0.001194	1.90	30.89	15.06	0.42
Reach-1	5225	67.00	86.17	88.42		88.62	0.001176	1.98	33.87	15.06	0.42
Reach-1	5225	75.20	86.17	88.61		88.82	0.001160	2.05	36.73	15.06	0.42
Reach-1	5225	86.10	86.17	89.31		89.48	0.000709	1.82	47.60	20.90	0.33
Reach-1	5225	94.60	86.17	89.43		89.62	0.000754	1.92	50.51	27.95	0.34
Reach-1	5225	20.70	86.17	87.24		87.33	0.001113	1.28	16.17	15.06	0.39
Reach-1	5225	484.00	86.17	92.28		92.60	0.000875	3.15	346.26	145.03	0.41
Reach-1	5257.2	28.10	86.45	87.45		87.63	0.000696	1.87	15.05	15.06	0.60
Reach-1	5257.2	46.80	86.45	87.94		88.16	0.000550	2.09	22.43	15.06	0.55
Reach-1	5257.2	58.50	86.45	88.24		88.48	0.000490	2.18	26.90	15.06	0.52
Reach-1	5257.2	66.60	86.45	88.43		88.69	0.000460	2.23	29.87	15.06	0.51
Reach-1	5257.2	74.50	86.45	88.62		88.89	0.000436	2.28	32.73	15.06	0.49
Reach-1	5257.2	85.00	86.45	89.32		89.52	0.000244	1.96	43.43	17.65	0.37
Reach-1	5257.2	93.00	86.45	89.44		89.66	0.000254	2.06	45.61	18.60	0.38
Reach-1	5257.2	20.70	86.45	87.27		87.41	0.000722	1.68	12.29	15.06	0.60
Reach-1	5257.2	484.00	86.45	91.77		93.21	0.000850	5.54	162.24	97.46	0.77
Reach-1	5257.25	Bridge									
Reach-1	5257.3	28.10	86.45	87.59	87.16	87.72	0.000463	1.64	17.11	15.06	0.49
Reach-1	5257.3	46.80	86.45	88.07	87.44	88.26	0.000423	1.92	24.42	15.06	0.48
Reach-1	5257.3	58.50	86.45	88.36	87.60	88.57	0.000397	2.03	28.80	15.06	0.47
Reach-1	5257.3	66.60	86.45	88.56	87.71	88.78	0.000382	2.10	31.75	15.06	0.46
Reach-1	5257.3	74.50	86.45	88.75	87.80	88.98	0.000369	2.15	34.58	15.06	0.45
Reach-1	5257.3	85.00	86.45	89.43	87.93	89.62	0.000214	1.89	45.44	18.53	0.35
Reach-1	5257.3	93.00	86.45	89.60	88.02	89.79	0.000213	1.95	48.59	19.82	0.35
Reach-1	5257.3	20.70	86.45	87.39	87.03	87.50	0.000459	1.46	14.15	15.06	0.48
Reach-1	5257.3	484.00	86.45	94.30	91.71	94.38	0.000047	1.69	442.11	125.39	0.19
Reach-1	5300	28.10	86.76	87.55	87.55	87.89	0.007075	2.59	10.86	15.80	1.00
Reach-1	5300	46.80	86.76	87.99	87.83	88.32	0.004042	2.53	18.46	18.09	0.80
Reach-1	5300	58.50	86.76	88.32	87.99	88.61	0.002604	2.39	24.52	18.36	0.66
Reach-1	5300	66.60	86.76	88.53	88.09	88.81	0.002139	2.35	28.35	18.37	0.60
Reach-1	5300	74.50	86.76	88.73	88.17	89.01	0.001831	2.33	32.03	18.37	0.56
Reach-1	5300	85.00	86.76	89.44	88.28	89.62	0.000836	1.89	45.07	18.39	0.38
Reach-1	5300	93.00	86.76	89.61	88.36	89.80	0.000820	1.93	48.14	18.39	0.38
Reach-1	5300	20.70	86.76	87.41	87.41	87.69	0.007519	2.38	8.71	15.09	1.00
Reach-1	5300	484.00	86.76	94.22	91.77	94.42	0.000338	2.40	414.82	121.70	0.28

HEC-RAS Plan: iadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5313	28.10	86.81	87.76		87.97	0.004082	2.05	15.25	30.00	0.77
Reach-1	5313	46.80	86.81	88.17		88.37	0.002256	2.06	27.63	30.00	0.62
Reach-1	5313	58.50	86.81	88.46		88.65	0.001563	2.00	36.46	30.00	0.53
Reach-1	5313	66.60	86.81	88.67		88.85	0.001280	1.97	42.48	30.00	0.49
Reach-1	5313	74.50	86.81	88.86		89.04	0.001081	1.96	48.35	30.00	0.46
Reach-1	5313	85.00	86.81	89.52		89.64	0.000490	1.62	68.10	30.07	0.33
Reach-1	5313	93.00	86.81	89.69		89.81	0.000471	1.66	73.29	30.76	0.32
Reach-1	5313	20.70	86.81	87.57		87.79	0.006189	2.09	9.90	18.16	0.90
Reach-1	5313	484.00	86.81	94.28		94.43	0.000207	2.15	531.66	145.48	0.25
Reach-1	5340	28.10	86.91	88.08	88.08	88.32	0.004445	2.56	21.97	45.00	0.83
Reach-1	5340	46.80	86.91	88.29	88.29	88.60	0.005060	3.09	31.12	45.00	0.91
Reach-1	5340	58.50	86.91	88.44		88.76	0.004554	3.19	38.05	45.00	0.88
Reach-1	5340	66.60	86.91	88.68		88.91	0.002930	2.85	48.60	45.00	0.73
Reach-1	5340	74.50	86.91	88.88		89.09	0.002186	2.67	57.94	45.00	0.64
Reach-1	5340	85.00	86.91	89.55		89.66	0.000807	2.01	87.92	45.00	0.41
Reach-1	5340	93.00	86.91	89.72		89.83	0.000741	2.02	95.83	45.00	0.40
Reach-1	5340	20.70	86.91	87.99	87.99	88.19	0.004047	2.27	17.55	45.00	0.78
Reach-1	5340	484.00	86.91	94.36		94.44	0.000238	2.26	638.07	161.33	0.27
Reach-1	5365	20.00	86.80	88.34		88.37	0.000335	0.91	36.62	41.80	0.24
Reach-1	5365	38.00	86.80	88.59		88.67	0.000614	1.38	47.46	42.93	0.34
Reach-1	5365	48.20	86.80	88.73		88.82	0.000723	1.58	53.31	43.53	0.37
Reach-1	5365	54.90	86.80	88.86		88.96	0.000702	1.63	59.31	44.13	0.37
Reach-1	5365	61.30	86.80	89.03		89.12	0.000637	1.64	66.58	44.85	0.36
Reach-1	5365	69.50	86.80	89.61		89.67	0.000319	1.36	93.41	47.41	0.27
Reach-1	5365	75.80	86.80	89.78		89.85	0.000298	1.38	101.75	48.18	0.26
Reach-1	5365	16.60	86.80	88.20		88.23	0.000352	0.87	30.91	41.20	0.25
Reach-1	5365	362.00	86.80	94.38		94.45	0.000128	1.70	600.03	167.36	0.20
Reach-1	5465	20.00	87.50	88.47	88.47	88.84	0.006291	2.71	7.94	13.89	0.96
Reach-1	5465	38.00	87.50	88.94	88.94	89.34	0.004059	2.96	19.82	37.47	0.83
Reach-1	5465	48.20	87.50	89.12	89.12	89.52	0.003578	3.04	27.41	42.20	0.80
Reach-1	5465	54.90	87.50	89.21	89.21	89.62	0.003618	3.17	30.92	43.21	0.81
Reach-1	5465	61.30	87.50	89.28	89.28	89.71	0.003625	3.27	34.23	44.15	0.82
Reach-1	5465	69.50	87.50	89.47		89.84	0.002833	3.11	42.72	46.45	0.74
Reach-1	5465	75.80	87.50	89.69		89.98	0.001993	2.82	53.40	49.20	0.63
Reach-1	5465	16.60	87.50	88.37	88.37	88.70	0.006816	2.58	6.65	12.05	0.98
Reach-1	5465	362.00	87.50	94.38		94.48	0.000236	2.15	462.68	135.63	0.26
Reach-1	5508	20.00	87.70	88.80		89.05	0.003530	2.25	11.16	22.35	0.74
Reach-1	5508	38.00	87.70	89.16		89.51	0.003607	2.81	21.20	33.75	0.79
Reach-1	5508	48.20	87.70	89.26		89.70	0.004223	3.20	24.80	36.83	0.86
Reach-1	5508	54.90	87.70	89.33		89.81	0.004404	3.38	27.60	39.05	0.89
Reach-1	5508	61.30	87.70	89.40		89.92	0.004547	3.54	30.25	41.05	0.91
Reach-1	5508	69.50	87.70	89.52		90.03	0.004249	3.59	35.28	44.59	0.89
Reach-1	5508	75.80	87.70	89.71		90.12	0.003109	3.31	44.47	50.43	0.78
Reach-1	5508	16.60	87.70	88.70		88.93	0.003660	2.13	9.11	19.04	0.74
Reach-1	5508	362.00	87.70	94.39		94.49	0.000250	2.17	468.86	135.99	0.27
Reach-1	5562	20.00	87.80	89.03		89.22	0.002698	2.04	18.10	54.49	0.64
Reach-1	5562	38.00	87.80	89.52		89.65	0.001598	1.95	45.34	56.72	0.52
Reach-1	5562	48.20	87.80	89.72		89.85	0.001440	2.01	57.66	66.25	0.50
Reach-1	5562	54.90	87.80	89.84		89.97	0.001388	2.07	65.57	71.71	0.50
Reach-1	5562	61.30	87.80	89.94		90.08	0.001353	2.12	73.07	76.53	0.49
Reach-1	5562	69.50	87.80	90.04		90.19	0.001368	2.21	81.28	79.75	0.50
Reach-1	5562	75.80	87.80	90.10		90.26	0.001425	2.30	86.07	80.02	0.51
Reach-1	5562	16.60	87.80	88.93		89.10	0.002694	1.93	13.73	35.62	0.63
Reach-1	5562	362.00	87.80	94.39		94.51	0.000320	2.32	535.41	150.11	0.29
Reach-1	5613	20.00	87.90	89.19		89.34	0.002153	1.87	18.43	37.88	0.58
Reach-1	5613	38.00	87.90	89.57		89.77	0.002174	2.26	33.33	42.62	0.60
Reach-1	5613	48.20	87.90	89.75		89.97	0.002115	2.41	41.61	48.60	0.61
Reach-1	5613	54.90	87.90	89.85		90.08	0.002102	2.51	46.95	52.09	0.61
Reach-1	5613	61.30	87.90	89.95		90.19	0.002097	2.60	51.99	55.19	0.62
Reach-1	5613	69.50	87.90	90.05		90.31	0.002164	2.73	57.50	57.77	0.63
Reach-1	5613	75.80	87.90	90.10		90.39	0.002282	2.86	60.75	58.82	0.65
Reach-1	5613	16.60	87.90	89.07		89.23	0.002383	1.85	13.91	37.61	0.60
Reach-1	5613	362.00	87.90	94.38		94.54	0.000415	2.64	543.36	170.91	0.34
Reach-1	5674	20.00	88.30	89.29	89.29	89.62	0.005550	2.59	10.43	29.33	0.91
Reach-1	5674	38.00	88.30	89.71	89.71	90.05	0.003787	2.82	30.15	57.16	0.80

HEC-RAS Plan: iadp rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Cnt W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5674	48.20	88.30	89.76		90.23	0.005071	3.35	33.17	57.62	0.93
Reach-1	5674	54.90	88.30	89.89		90.33	0.004353	3.30	40.56	58.72	0.88
Reach-1	5674	61.30	88.30	90.00		90.42	0.003947	3.30	46.92	59.65	0.85
Reach-1	5674	69.50	88.30	90.11		90.53	0.003754	3.37	53.45	60.19	0.84
Reach-1	5674	75.80	88.30	90.17		90.61	0.003768	3.46	57.41	60.51	0.84
Reach-1	5674	16.60	88.30	89.18	89.18	89.50	0.006272	2.51	7.70	21.84	0.94
Reach-1	5674	362.00	88.30	94.39		94.58	0.000500	2.88	507.65	177.37	0.38
Reach-1	5734	20.00	88.60	89.61	89.56	89.94	0.005226	2.56	8.94	16.87	0.88
Reach-1	5734	38.00	88.60	90.01	90.01	90.50	0.004888	3.19	17.59	26.79	0.91
Reach-1	5734	48.20	88.60	90.19	90.19	90.75	0.004711	3.43	22.75	29.29	0.91
Reach-1	5734	54.90	88.60	90.30	90.30	90.89	0.004641	3.58	26.02	30.77	0.92
Reach-1	5734	61.30	88.60	90.41	90.41	91.03	0.004501	3.69	29.38	32.22	0.92
Reach-1	5734	69.50	88.60	90.43	90.43	91.20	0.005441	4.10	30.25	32.59	1.01
Reach-1	5734	75.80	88.60	90.48	90.48	91.32	0.005822	4.32	31.82	33.23	1.05
Reach-1	5734	16.60	88.60	89.56		89.82	0.004479	2.28	8.09	15.54	0.81
Reach-1	5734	362.00	88.60	94.37		94.63	0.000700	3.29	521.18	185.60	0.44
Reach-1	5764	20.00	88.80	89.93	89.60	90.04	0.001581	1.48	14.29	18.68	0.50
Reach-1	5764	38.00	88.80	90.44	89.90	90.60	0.001246	1.77	25.00	23.45	0.48
Reach-1	5764	48.20	88.80	90.66	90.06	90.85	0.001240	1.94	31.69	43.01	0.49
Reach-1	5764	54.90	88.80	90.79	90.15	91.00	0.001209	2.02	38.58	59.21	0.49
Reach-1	5764	61.30	88.80	90.92	90.23	91.13	0.001168	2.08	46.84	74.08	0.48
Reach-1	5764	69.50	88.80	91.11	90.34	91.31	0.001012	2.06	64.92	111.76	0.46
Reach-1	5764	75.80	88.80	91.26	90.41	91.44	0.000896	2.03	81.74	119.75	0.43
Reach-1	5764	16.60	88.80	89.82	89.53	89.92	0.001751	1.41	12.13	17.67	0.51
Reach-1	5764	362.00	88.80	94.51	92.38	94.66	0.000354	2.33	606.03	205.13	0.32
Reach-1	5822.2	20.00	88.90	90.02		90.16	0.001869	1.65	12.13	10.84	0.50
Reach-1	5822.2	38.00	88.90	90.50		90.74	0.002282	2.20	17.28	10.86	0.56
Reach-1	5822.2	48.20	88.90	90.70		91.01	0.002550	2.47	19.50	10.86	0.59
Reach-1	5822.2	54.90	88.90	90.82		91.18	0.002719	2.64	20.82	10.87	0.61
Reach-1	5822.2	61.30	88.90	90.93		91.33	0.002880	2.79	21.99	10.87	0.63
Reach-1	5822.2	69.50	88.90	91.09		91.53	0.002959	2.93	23.72	10.88	0.63
Reach-1	5822.2	75.80	88.90	91.21		91.68	0.003018	3.03	24.99	10.88	0.64
Reach-1	5822.2	16.60	88.90	89.91		90.03	0.001775	1.52	10.95	10.84	0.48
Reach-1	5822.2	362.00	88.90	94.42	94.42	95.96	0.003563	5.68	110.91	83.39	0.77
Reach-1	5822.25	Bridge									
Reach-1	5822.3	20.00	88.90	90.24	89.60	90.34	0.001069	1.38	14.54	10.85	0.38
Reach-1	5822.3	38.00	88.90	90.83	89.98	91.00	0.001286	1.82	20.91	10.87	0.42
Reach-1	5822.3	48.20	88.90	91.11	90.16	91.31	0.001388	2.02	23.92	10.88	0.43
Reach-1	5822.3	54.90	88.90	91.28	90.28	91.51	0.001447	2.13	25.77	10.89	0.44
Reach-1	5822.3	61.30	88.90	91.43	90.39	91.69	0.001499	2.23	27.46	10.89	0.45
Reach-1	5822.3	69.50	88.90	91.63	90.52	91.91	0.001544	2.34	29.64	10.90	0.45
Reach-1	5822.3	75.80	88.90	91.84	90.61	92.13	0.001444	2.37	32.00	11.71	0.44
Reach-1	5822.3	16.60	88.90	90.11	89.52	90.19	0.001016	1.27	13.10	10.84	0.37
Reach-1	5822.3	362.00	88.90	96.67	94.42	97.06	0.000716	3.20	319.53	102.43	0.37
Reach-1	5822.4	20.00	88.90	90.26		90.35	0.001038	1.36	14.68	10.85	0.37
Reach-1	5822.4	38.00	88.90	90.85		91.01	0.001254	1.80	21.09	10.87	0.41
Reach-1	5822.4	48.20	88.90	91.13		91.33	0.001355	2.00	24.12	10.88	0.43
Reach-1	5822.4	54.90	88.90	91.30		91.52	0.001414	2.11	25.98	10.89	0.44
Reach-1	5822.4	61.30	88.90	91.45		91.70	0.001465	2.22	27.67	10.89	0.44
Reach-1	5822.4	69.50	88.90	91.65		91.93	0.001510	2.33	29.87	10.90	0.45
Reach-1	5822.4	75.80	88.90	91.86		92.15	0.001413	2.36	32.22	11.80	0.44
Reach-1	5822.4	16.60	88.90	90.12		90.20	0.000985	1.25	13.23	10.84	0.36
Reach-1	5822.4	362.00	88.90	96.68		97.07	0.000711	3.19	320.53	102.52	0.37
Reach-1	5822.5	20.00	88.90	90.26		90.37	0.001228	1.49	13.42	10.75	0.43
Reach-1	5822.5	38.00	88.90	90.85		91.03	0.001354	1.90	20.00	11.52	0.46
Reach-1	5822.5	48.20	88.90	91.13		91.35	0.001398	2.07	23.29	11.88	0.47
Reach-1	5822.5	54.90	88.90	91.31		91.54	0.001417	2.16	25.37	12.10	0.48
Reach-1	5822.5	61.30	88.90	91.46		91.72	0.001430	2.25	27.30	12.31	0.48
Reach-1	5822.5	69.50	88.90	91.67		91.94	0.001424	2.33	29.85	12.57	0.48
Reach-1	5822.5	75.80	88.90	91.89		92.16	0.001316	2.32	32.63	12.85	0.47
Reach-1	5822.5	16.60	88.90	90.13		90.22	0.001188	1.38	11.99	10.58	0.42
Reach-1	5822.5	362.00	88.90	97.01		97.15	0.000256	2.13	577.29	165.28	0.25
Reach-1	5880	20.00	89.10	90.22	90.07	90.46	0.003279	2.20	12.61	24.25	0.71
Reach-1	5880	38.00	89.10	90.86	90.48	91.09	0.001744	2.25	31.57	32.60	0.57

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	5880	48.20	89.10	91.16	90.67	91.39	0.001456	2.31	41.71	34.65	0.53
Reach-1	5880	54.90	89.10	91.36	90.77	91.58	0.001317	2.34	48.44	35.98	0.52
Reach-1	5880	61.30	89.10	91.52	90.86	91.76	0.001244	2.39	54.60	38.73	0.51
Reach-1	5880	69.50	89.10	91.71	90.96	91.98	0.001261	2.54	63.35	53.52	0.52
Reach-1	5880	75.80	89.10	91.94	91.04	92.19	0.001094	2.51	77.32	71.03	0.49
Reach-1	5880	16.60	89.10	90.08	89.97	90.32	0.004054	2.20	9.32	21.14	0.77
Reach-1	5880	362.00	89.10	97.06	93.39	97.16	0.000196	2.16	700.60	158.62	0.25
Reach-1	5905	20.00	89.95	90.93	90.93	91.28	0.005879	2.65	9.29	23.61	0.93
Reach-1	5905	38.00	89.95	91.33	91.33	91.77	0.004765	3.10	20.82	31.30	0.90
Reach-1	5905	48.20	89.95	91.49	91.49	91.99	0.004688	3.35	26.17	33.02	0.91
Reach-1	5905	54.90	89.95	91.59	91.59	92.12	0.004669	3.50	29.42	33.65	0.92
Reach-1	5905	61.30	89.95	91.68	91.68	92.24	0.004691	3.64	32.29	34.08	0.93
Reach-1	5905	69.50	89.95	91.79	91.79	92.39	0.004634	3.78	36.08	34.64	0.93
Reach-1	5905	75.80	89.95	91.86	91.86	92.50	0.004639	3.90	38.76	35.02	0.94
Reach-1	5905	16.60	89.95	90.82	90.82	91.15	0.006650	2.56	7.08	16.98	0.97
Reach-1	5905	362.00	89.95	96.94		97.23	0.000502	3.17	429.71	121.72	0.39
Reach-1	5917	20.00	90.01	91.27	90.70	91.38	0.001094	1.44	13.90	27.09	0.41
Reach-1	5917	38.00	90.01	91.63	91.07	91.87	0.001780	2.13	17.87	28.21	0.53
Reach-1	5917	48.20	90.01	91.77	91.26	92.08	0.002241	2.50	19.31	28.42	0.60
Reach-1	5917	54.90	90.01	91.82	91.37	92.21	0.002628	2.75	19.94	28.51	0.65
Reach-1	5917	61.30	90.01	91.86	91.48	92.32	0.003093	3.02	20.31	28.56	0.71
Reach-1	5917	69.50	90.01	91.84	91.61	92.45	0.004107	3.46	20.10	28.53	0.82
Reach-1	5917	75.80	90.01	91.90	91.70	92.58	0.004431	3.66	20.73	28.62	0.85
Reach-1	5917	16.60	90.01	91.17	90.62	91.25	0.001006	1.31	12.70	26.66	0.39
Reach-1	5917	362.00	90.01	97.04	94.70	97.25	0.000446	2.68	441.69	117.43	0.32
Reach-1	5918	20.00	90.51	91.22	91.15	91.45	0.001457	2.10	9.52	20.44	0.85
Reach-1	5918	38.00	90.51	91.60	91.46	91.91	0.001108	2.45	15.52	22.36	0.79
Reach-1	5918	48.20	90.51	91.74	91.61	92.12	0.001133	2.71	17.78	22.97	0.82
Reach-1	5918	54.90	90.51	91.81	91.69	92.24	0.001225	2.92	18.78	23.24	0.86
Reach-1	5918	61.30	90.51	91.84	91.77	92.35	0.001379	3.17	19.37	23.39	0.92
Reach-1	5918	69.50	90.51	91.88	91.88	92.50	0.001615	3.49	19.92	23.54	1.00
Reach-1	5918	75.80	90.51	92.11	91.95	92.64	0.001081	3.20	23.67	24.88	0.84
Reach-1	5918	16.60	90.51	91.10	91.08	91.34	0.002018	2.17	7.64	19.63	0.96
Reach-1	5918	362.00	90.51	97.30	94.37	97.31	0.000008	0.75	678.59	215.06	0.09
Reach-1	5967	Bridge									
Reach-1	6017	20.00	90.51	91.72	91.15	91.79	0.000210	1.15	17.41	22.87	0.35
Reach-1	6017	38.00	90.51	92.32	91.46	92.42	0.000175	1.41	27.00	26.40	0.35
Reach-1	6017	48.20	90.51	92.62	91.61	92.73	0.000165	1.52	31.72	45.19	0.34
Reach-1	6017	54.90	90.51	92.80	91.69	92.93	0.000159	1.58	34.64	72.79	0.34
Reach-1	6017	61.30	90.51	92.96	91.77	93.10	0.000155	1.64	37.30	97.97	0.34
Reach-1	6017	69.50	90.51	93.17	91.87	93.32	0.000150	1.71	40.61	105.12	0.34
Reach-1	6017	75.80	90.51	93.33	91.95	93.48	0.000147	1.76	43.06	106.70	0.34
Reach-1	6017	16.60	90.51	91.59	91.08	91.65	0.000222	1.08	15.30	22.30	0.35
Reach-1	6017	362.00	90.51	97.33	94.37	97.35	0.000008	0.74	685.76	215.94	0.09
Reach-1	6072	20.00	91.30	92.33	92.33	92.55	0.007510	2.22	12.71	38.53	0.76
Reach-1	6072	38.00	91.30	92.62	92.62	92.82	0.005888	2.39	28.27	63.34	0.71
Reach-1	6072	48.20	91.30	92.70	92.70	92.92	0.006420	2.60	33.17	64.10	0.74
Reach-1	6072	54.90	91.30	92.79		92.99	0.005428	2.51	39.18	65.00	0.69
Reach-1	6072	61.30	91.30	93.03		93.14	0.002730	1.98	54.62	67.27	0.50
Reach-1	6072	69.50	91.30	93.29		93.37	0.001528	1.65	73.05	69.93	0.39
Reach-1	6072	75.80	91.30	93.47		93.53	0.001140	1.51	85.73	71.70	0.34
Reach-1	6072	16.60	91.30	92.24	92.24	92.47	0.008482	2.20	9.58	30.36	0.79
Reach-1	6072	362.00	91.30	97.32		97.35	0.000205	1.31	621.05	253.05	0.17
Reach-1	6132	20.00	91.30	92.65		92.68	0.000964	0.98	37.44	70.87	0.29
Reach-1	6132	38.00	91.30	92.90		92.94	0.001149	1.22	55.62	72.58	0.32
Reach-1	6132	48.20	91.30	93.00		93.05	0.001283	1.35	63.02	73.27	0.35
Reach-1	6132	54.90	91.30	93.06		93.11	0.001391	1.43	66.96	73.63	0.36
Reach-1	6132	61.30	91.30	93.17		93.22	0.001234	1.41	75.06	74.37	0.34
Reach-1	6132	69.50	91.30	93.37		93.42	0.000897	1.30	90.69	75.78	0.30
Reach-1	6132	75.80	91.30	93.53		93.57	0.000729	1.23	102.85	76.85	0.27
Reach-1	6132	16.60	91.30	92.57		92.60	0.000985	0.95	32.20	70.37	0.29
Reach-1	6132	362.00	91.30	97.32		97.38	0.000389	1.80	475.78	219.12	0.24
Reach-1	6182	20.00	91.80	92.74	92.74	92.89	0.007112	2.01	16.45	50.43	0.73
Reach-1	6182	38.00	91.80	92.90	92.90	93.11	0.008847	2.54	24.89	51.26	0.84

HEC-RAS Plan: iadp rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	6182	48.20	91.80	92.97		93.22	0.009976	2.83	28.29	51.59	*
Reach-1	6182	54.90	91.80	93.02		93.28	0.009765	2.90	31.24	51.88	*
Reach-1	6182	61.30	91.80	93.15		93.35	0.007111	2.66	37.61	52.48	0.78
Reach-1	6182	69.50	91.80	93.36		93.51	0.004157	2.27	49.02	53.56	0.61
Reach-1	6182	75.80	91.80	93.52		93.64	0.003037	2.09	57.65	54.47	0.53
Reach-1	6182	16.60	91.80	92.69	92.69	92.83	0.006769	1.88	14.29	50.21	0.70
Reach-1	6182	362.00	91.80	97.32		97.40	0.000448	1.82	316.88	79.26	0.25
Reach-1	6272	20.00	92.30	93.32	93.28	93.63	0.009508	2.49	8.83	15.38	0.85
Reach-1	6272	38.00	92.30	93.78	93.78	94.11	0.006356	2.71	19.63	33.20	0.75
Reach-1	6272	48.20	92.30	93.91	93.91	94.26	0.006666	2.94	23.72	33.79	0.78
Reach-1	6272	54.90	92.30	93.98	93.98	94.36	0.006828	3.07	26.17	34.14	0.79
Reach-1	6272	61.30	92.30	94.05	94.05	94.44	0.006895	3.18	28.50	34.47	0.80
Reach-1	6272	69.50	92.30	94.12	94.12	94.55	0.007031	3.31	31.22	34.85	0.82
Reach-1	6272	75.80	92.30	94.18	94.18	94.62	0.007180	3.42	33.11	35.12	0.83
Reach-1	6272	16.60	92.30	93.26		93.51	0.008447	2.24	7.96	14.22	0.79
Reach-1	6272	362.00	92.30	97.18		97.54	0.001979	3.52	162.54	51.95	0.52
Reach-1	6316	20.00	92.61	93.73	93.73	94.29	0.011583	3.31	6.04	22.41	1.00
Reach-1	6316	38.00	92.61	94.33	94.33	95.18	0.010021	4.10	9.27	43.51	1.00
Reach-1	6316	48.20	92.61	94.62	94.62	95.63	0.009547	4.44	10.84	57.27	1.00
Reach-1	6316	54.90	92.61	94.81	94.81	95.90	0.009220	4.63	11.85	63.17	1.00
Reach-1	6316	61.30	92.61	94.97	94.97	96.15	0.009065	4.82	12.72	68.30	1.00
Reach-1	6316	69.50	92.61	95.18	95.18	96.46	0.008763	5.01	13.86	75.15	1.00
Reach-1	6316	75.80	92.61	95.33	95.33	96.69	0.008603	5.16	14.68	80.13	1.00
Reach-1	6316	16.60	92.61	93.60	93.60	94.09	0.012018	3.11	5.34	22.06	1.00
Reach-1	6316	362.00	92.61	99.60	99.60	99.61	0.000081	0.94	897.76	279.93	0.11
Reach-1	6320	20.00	93.20	94.32	94.32	94.88	0.001593	3.31	6.04	92.98	1.00
Reach-1	6320	38.00	93.20	94.91	94.91	95.77	0.001390	4.11	9.25	126.92	1.00
Reach-1	6320	48.20	93.20	95.21	95.21	96.21	0.001312	4.44	10.86	131.78	1.00
Reach-1	6320	54.90	93.20	95.39	95.39	96.49	0.001273	4.63	11.85	133.34	1.00
Reach-1	6320	61.30	93.20	95.55	95.55	96.74	0.001253	4.82	12.72	149.24	1.00
Reach-1	6320	65.00	93.20	95.65	95.65	96.88	0.001229	4.90	13.25	156.60	1.00
Reach-1	6320	75.80	93.20	95.92	95.92	97.27	0.001187	5.16	14.68	176.71	1.00
Reach-1	6320	16.60	93.20	94.19	94.19	94.68	0.001655	3.11	5.34	79.08	1.00
Reach-1	6320	356.00	93.20	100.00	100.00	100.00	0.000002	0.34	1344.16	295.01	0.04
Reach-1	6361	Bridge									
Reach-1	6406	20.00	93.20	95.15	94.31	95.33	0.000251	1.90	10.53	17.44	0.43
Reach-1	6406	38.00	93.20	96.33	94.91	96.59	0.000186	2.25	16.91	20.99	0.41
Reach-1	6406	48.20	93.20	97.70	95.21	97.90	0.000089	1.98	24.34	25.11	0.30
Reach-1	6406	54.90	93.20	98.72	95.39	98.89	0.000059	1.84	29.80	28.15	0.25
Reach-1	6406	61.30	93.20	99.76	95.55	99.91	0.000041	1.73	35.43	31.27	0.22
Reach-1	6406	65.00	93.20	100.03	95.64	100.05	0.000005	0.62	154.42	260.15	0.08
Reach-1	6406	75.80	93.20	100.11	95.91	100.13	0.000006	0.70	174.51	260.51	0.08
Reach-1	6406	16.60	93.20	94.96	94.18	95.11	0.000244	1.75	9.49	16.87	0.42
Reach-1	6406	356.00	93.20	100.78	100.00	100.90	0.000054	2.18	350.28	263.59	0.25
Reach-1	6453	20.00	93.51	95.35		95.35	0.000045	0.27	129.05	151.49	0.07
Reach-1	6453	38.00	93.51	96.61		96.61	0.000010	0.18	382.07	243.16	0.03
Reach-1	6453	48.20	93.51	97.92		97.92	0.000002	0.12	719.33	263.63	0.02
Reach-1	6453	54.90	93.51	98.91		98.91	0.000001	0.09	980.67	268.54	0.01
Reach-1	6453	61.30	93.51	99.93		99.93	0.000001	0.08	1257.04	273.64	0.01
Reach-1	6453	65.00	93.51	100.05		100.05	0.000001	0.08	1290.12	274.18	0.01
Reach-1	6453	75.80	93.51	100.13		100.13	0.000001	0.10	1312.22	274.49	0.01
Reach-1	6453	16.60	93.51	95.13		95.13	0.000067	0.30	96.30	143.27	0.08
Reach-1	6453	356.00	93.51	100.91		100.91	0.000013	0.38	1527.31	277.45	0.04
Reach-1	6600	20.00	93.72	95.34		95.37	0.000735	0.98	34.98	58.06	0.26
Reach-1	6600	38.00	93.72	96.61		96.62	0.000054	0.40	204.36	174.11	0.08
Reach-1	6600	48.20	93.72	97.92		97.92	0.000008	0.21	437.17	180.73	0.03
Reach-1	6600	54.90	93.72	98.91		98.91	0.000004	0.16	617.38	186.27	0.02
Reach-1	6600	61.30	93.72	99.93		99.93	0.000002	0.13	810.25	192.08	0.02
Reach-1	6600	65.00	93.72	100.05		100.05	0.000002	0.13	833.48	192.72	0.02
Reach-1	6600	75.80	93.72	100.13		100.13	0.000003	0.15	849.02	193.09	0.02
Reach-1	6600	16.60	93.72	95.10		95.16	0.001369	1.19	21.85	53.83	0.34
Reach-1	6600	356.00	93.72	100.90		100.91	0.000034	0.60	1000.54	196.66	0.07
Reach-1	6705	20.00	94.00	95.41	95.05	95.48	0.001618	1.31	25.17	53.19	0.37
Reach-1	6705	38.00	94.00	96.62	95.39	96.62	0.000128	0.58	137.37	120.33	0.12

HEC-RAS Plan: jadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	6705	48.20	94.00	97.92	95.50	97.93	0.000016	0.28	347.16	179.98	0.05
Reach-1	6705	54.90	94.00	98.91	95.57	98.91	0.000006	0.19	528.38	187.67	0.03
Reach-1	6705	61.30	94.00	99.93	95.62	99.93	0.000003	0.15	722.95	194.05	0.02
Reach-1	6705	65.00	94.00	100.05	95.65	100.05	0.000003	0.15	746.43	194.72	0.02
Reach-1	6705	75.80	94.00	100.13	95.74	100.13	0.000004	0.18	762.13	195.08	0.02
Reach-1	6705	16.60	94.00	95.25	94.88	95.34	0.002242	1.41	17.47	43.16	0.43
Reach-1	6705	356.00	94.00	100.91	96.74	100.92	0.000045	0.67	915.43	198.58	0.08
Reach-1	6765	20.00	94.80	95.58	95.50	95.63	0.004461	1.36	22.07	47.57	0.55
Reach-1	6765	38.00	94.80	96.63	95.56	96.63	0.000230	0.59	126.94	183.09	0.15
Reach-1	6765	48.20	94.80	97.93	95.63	97.93	0.000015	0.22	391.49	211.38	0.04
Reach-1	6765	54.90	94.80	98.91	95.70	98.91	0.000005	0.15	601.15	215.71	0.02
Reach-1	6765	61.30	94.80	99.93	95.72	99.93	0.000002	0.12	823.11	219.87	0.02
Reach-1	6765	65.00	94.80	100.05	95.74	100.05	0.000002	0.12	849.69	220.38	0.02
Reach-1	6765	75.80	94.80	100.13	95.81	100.13	0.000003	0.14	867.48	220.73	0.02
Reach-1	6765	16.60	94.80	95.50	95.50	95.55	0.005126	1.35	18.50	45.55	0.58
Reach-1	6765	356.00	94.80	100.91	96.82	100.92	0.000036	0.55	1041.79	224.12	0.07
Reach-1	6805	20.00	95.30	96.18	96.18	96.27	0.005547	1.69	25.74	120.06	0.63
Reach-1	6805	38.00	95.30	96.63	96.28	96.65	0.000764	0.87	85.98	149.93	0.25
Reach-1	6805	48.20	95.30	97.93	96.32	97.93	0.000022	0.24	363.09	239.86	0.05
Reach-1	6805	54.90	95.30	98.91	96.35	98.91	0.000006	0.16	602.60	248.04	0.03
Reach-1	6805	61.30	95.30	99.93	96.37	99.93	0.000002	0.12	859.39	255.94	0.02
Reach-1	6805	65.00	95.30	100.05	96.38	100.05	0.000002	0.12	890.35	256.72	0.02
Reach-1	6805	75.80	95.30	100.13	96.42	100.13	0.000003	0.14	911.08	257.09	0.02
Reach-1	6805	16.60	95.30	96.15	96.15	96.23	0.005117	1.58	22.64	118.76	0.60
Reach-1	6805	356.00	95.30	100.91	97.09	100.92	0.000035	0.52	1114.56	260.73	0.07
Reach-1	6895	20.00	95.60	96.63		96.75	0.005022	1.82	20.88	84.30	0.62
Reach-1	6895	38.00	95.60	96.77	96.77	96.93	0.006440	2.28	34.00	98.51	0.72
Reach-1	6895	48.20	95.60	97.93		97.93	0.000092	0.45	221.41	213.85	0.10
Reach-1	6895	54.90	95.60	98.91		98.91	0.000015	0.23	432.42	216.86	0.04
Reach-1	6895	61.30	95.60	99.93		99.93	0.000005	0.16	654.85	219.79	0.03
Reach-1	6895	65.00	95.60	100.05		100.05	0.000005	0.16	681.41	220.21	0.02
Reach-1	6895	75.80	95.60	100.13		100.13	0.000006	0.18	699.20	220.56	0.03
Reach-1	6895	16.60	95.60	96.58		96.70	0.005048	1.75	16.98	79.57	0.62
Reach-1	6895	356.00	95.60	100.92		100.92	0.000065	0.67	874.19	223.98	0.09
Reach-1	6980	20.00	95.80	96.98	96.79	97.07	0.002981	1.56	20.64	47.26	0.49
Reach-1	6980	38.00	95.80	97.21	97.12	97.33	0.003630	1.97	35.77	71.35	0.56
Reach-1	6980	48.20	95.80	97.93	97.19	97.95	0.000450	0.94	93.72	88.84	0.21
Reach-1	6980	54.90	95.80	98.91	97.24	98.91	0.000070	0.48	208.95	128.76	0.09
Reach-1	6980	61.30	95.80	99.93	97.27	99.93	0.000020	0.31	344.64	136.53	0.05
Reach-1	6980	65.00	95.80	100.05	97.30	100.05	0.000019	0.32	361.17	137.22	0.05
Reach-1	6980	75.80	95.80	100.13	97.35	100.13	0.000024	0.36	372.24	137.60	0.06
Reach-1	6980	16.60	95.80	96.93	96.72	97.01	0.002649	1.42	18.29	44.14	0.46
Reach-1	6980	356.00	95.80	100.91	98.38	100.94	0.000238	1.26	481.04	141.24	0.18
Reach-1	7055	20.00	96.00	97.20		97.33	0.003655	1.75	17.00	41.61	0.55
Reach-1	7055	38.00	96.00	97.46		97.63	0.004071	2.14	28.12	43.05	0.60
Reach-1	7055	48.20	96.00	97.95		98.02	0.001391	1.55	49.59	45.72	0.37
Reach-1	7055	54.90	96.00	98.91		98.92	0.000181	0.74	154.60	131.36	0.14
Reach-1	7055	61.30	96.00	99.93		99.93	0.000034	0.40	292.83	137.32	0.07
Reach-1	7055	65.00	96.00	100.05		100.05	0.000032	0.39	309.42	137.74	0.06
Reach-1	7055	75.80	96.00	100.13		100.13	0.000039	0.44	320.58	138.15	0.07
Reach-1	7055	16.60	96.00	97.13		97.25	0.003668	1.67	13.99	41.21	0.54
Reach-1	7055	356.00	96.00	100.92		100.97	0.000345	1.48	431.74	142.11	0.22
Reach-1	7420	20.00	96.74	97.82	97.82	98.23	0.013541	2.83	7.16	9.19	0.99
Reach-1	7420	38.00	96.74	98.34	98.34	98.63	0.006426	2.64	30.13	63.11	0.74
Reach-1	7420	48.20	96.74	98.45	98.45	98.77	0.006758	2.86	37.35	63.67	0.77
Reach-1	7420	54.90	96.74	98.88		99.02	0.002395	2.03	65.02	65.76	0.48
Reach-1	7420	61.30	96.74	99.92		99.95	0.000401	1.12	135.08	69.44	0.21
Reach-1	7420	65.00	96.74	100.04		100.07	0.000379	1.12	143.48	69.87	0.21
Reach-1	7420	75.80	96.74	100.12		100.16	0.000463	1.26	148.94	70.18	0.23
Reach-1	7420	16.60	96.74	97.71	97.71	98.09	0.014268	2.70	6.18	8.73	1.00
Reach-1	7420	231.00	96.74	100.90		101.09	0.001692	2.80	205.13	73.22	0.45
Reach-1	7500	20.00	97.50	98.74		98.93	0.005800	2.09	19.36	54.99	0.67
Reach-1	7500	38.00	97.50	98.91		99.25	0.009761	3.00	28.54	57.25	0.89
Reach-1	7500	48.20	97.50	99.03		99.39	0.009492	3.17	35.91	60.61	0.89
Reach-1	7500	54.90	97.50	99.13	99.13	99.47	0.008644	3.18	42.21	66.52	0.86

HEC-RAS Plan: jadp rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	7500	61 30	97 50	99 94		100.00	0.001124	1.56	120 51	136 19	0 34
Reach-1	7500	65 00	97 50	100 06		100.11	0.000946	1.48	137 67	144 78	0 31
Reach-1	7500	75 80	97 50	100 15		100.21	0.001052	1.60	150.23	148.41	0.33
Reach-1	7500	16 60	97 50	98 65		98.85	0.006534	2.07	14 25	53.70	0.70
Reach-1	7500	231 00	97 50	101 10		101.20	0.001628	2.48	305 72	174 99	0.43
Reach-1	7600	20 00	98 67	99 48	99.48	99.77	0.012555	2.39	9.87	24 47	0.94
Reach-1	7600	38 00	98 67	99 83		100.17	0.009965	2.74	20.83	42.56	0.89
Reach-1	7600	48 20	98 67	100 02	100.02	100.34	0.008005	2.73	32.19	74.11	0.82
Reach-1	7600	54 90	98 67	100 09	100.09	100.43	0.007914	2.82	38.00	83.48	0.82
Reach-1	7600	61 30	98 67	100 17	100.17	100.50	0.007359	2.84	45.31	97.55	0.80
Reach-1	7600	65 00	98 67	100 20	100.20	100.54	0.007467	2.91	48.19	102.57	0.81
Reach-1	7600	75 80	98 67	100 35	100.35	100.64	0.006020	2.80	65.48	123.65	0.74
Reach-1	7600	16 60	98 67	99 44	99.40	99.67	0.010889	2.13	8.87	22.61	0.87
Reach-1	7600	231 00	98 67	101 22		101.41	0.003632	2.96	233.89	233.35	0.62
Reach-1	7650	20.00	98 92	100 00		100.30	0.008983	2.40	8.41	10.72	0.82
Reach-1	7650	38 00	98 92	100 47	100.47	100.76	0.006299	2.58	29.22	79.65	0.73
Reach-1	7650	48 20	98 92	100 61	100.61	100.89	0.005807	2.66	41.96	94.08	0.71
Reach-1	7650	54.90	98 92	100 67	100.67	100.97	0.005944	2.77	48.14	99.39	0.72
Reach-1	7650	61.30	98 92	100.73	100.73	101.04	0.006026	2.86	53.99	104.17	0.73
Reach-1	7650	65 00	98.92	100 76	100.76	101.07	0.006143	2.92	56.93	106.49	0.74
Reach-1	7650	75.80	98 92	100 84	100.84	101.17	0.006271	3.05	66.18	113.48	0.76
Reach-1	7650	16.60	98.92	99.91		100.16	0.008811	2.23	7.49	9.77	0.80
Reach-1	7650	231.00	98.92	101.52	101.52	101.83	0.006117	3.79	207.22	266.29	0.79
Reach-1	7700	20.00	99.56	100 53		100.75	0.008942	2.11	9.47	13.36	0.80
Reach-1	7700	38 00	99 56	100.79	100.76	101.22	0.011747	2.88	13.18	14.28	0.95
Reach-1	7700	48.20	99 56	100 93	100.93	101.45	0.012321	3.19	15.20	15.77	0.99
Reach-1	7700	54 90	99 56	101.06	101.06	101.59	0.010939	3.21	18.04	29.34	0.95
Reach-1	7700	61 30	99.56	101 18	101.18	101.70	0.009815	3.22	21.99	36.61	0.91
Reach-1	7700	65 00	99 56	101.24	101.24	101.76	0.009375	3.23	24.34	40.32	0.90
Reach-1	7700	75.80	99 56	101.39	101.39	101.92	0.008685	3.29	31.04	49.38	0.88
Reach-1	7700	16.60	99.56	100 42		100.64	0.009935	2.04	8.12	13.05	0.83
Reach-1	7700	231 00	99.56	102.20	102.20	102.52	0.005329	3.44	226.11	312.27	0.74
Reach-1	7750	20.00	100 59	101 17	101.17	101.39	0.016375	2.08	9.60	22.10	1.01
Reach-1	7750	38.00	100.59	101.55		101.75	0.008829	1.99	19.12	29.69	0.79
Reach-1	7750	48.20	100.59	101.74		101.92	0.006649	1.91	25.29	37.35	0.70
Reach-1	7750	54.90	100.59	101.82		102.02	0.006006	1.95	28.92	46.38	0.68
Reach-1	7750	61.30	100.59	101.90		102.10	0.005615	1.99	32.67	54.17	0.67
Reach-1	7750	65.00	100.59	101.94		102.14	0.005400	2.01	35.08	58.61	0.66
Reach-1	7750	75.80	100.59	102.06		102.27	0.004781	2.05	44.08	94.54	0.63
Reach-1	7750	16.60	100.59	101.12	101.12	101.31	0.017007	1.97	8.43	21.78	1.01
Reach-1	7750	231.00	100.59	102.71	102.71	103.07	0.005499	3.01	176.21	296.98	0.73
Reach-1	7800	20.00	101.13	101.99	101.99	102.24	0.015225	2.23	8.99	17.74	1.00
Reach-1	7800	38.00	101 13	102.28	102.28	102.59	0.011341	2.49	20.58	48.94	0.92
Reach-1	7800	48.20	101.13	102.40	102.40	102.74	0.010828	2.66	26.71	55.60	0.92
Reach-1	7800	54.90	101.13	102.45	102.45	102.83	0.011684	2.85	29.27	58.16	0.96
Reach-1	7800	61.30	101.13	102.50	102.50	102.91	0.012001	2.99	32.21	60.97	0.98
Reach-1	7800	65.00	101.13	102.60	102.60	102.95	0.009216	2.79	39.36	69.14	0.87
Reach-1	7800	75 80	101 13	102 68	102.68	103.07	0.009505	2.95	44.74	69.43	0.89
Reach-1	7800	16.60	101.13	101.92	101.92	102.15	0.015866	2.11	7.85	17.27	1.00
Reach-1	7800	231.00	101.13	103 01	103.01	104.70	0.032979	6.41	67.94	110.98	1.73
Reach-1	7850	20.00	101.67	102 60		102.86	0.010282	2.26	8.87	12.59	0.86
Reach-1	7850	38 00	101.67	102.89	102.89	103.35	0.012917	3.01	12.61	13.63	1.00
Reach-1	7850	48.20	101.67	103.11	103.11	103.58	0.010807	3.06	17.48	38.45	0.94
Reach-1	7850	54.90	101 67	103 24	103.24	103.70	0.009511	3.04	23.78	56.37	0.89
Reach-1	7850	61.30	101 67	103.39	103.39	103.79	0.007690	2.90	33.85	73.51	0.81
Reach-1	7850	65.00	101 67	103.43	103.43	103.84	0.007639	2.94	37.00	74.95	0.81
Reach-1	7850	75 80	101.67	103.55	103.55	103.97	0.007502	3.04	45.77	79.53	0.81
Reach-1	7850	16 60	101 67	102 54		102.75	0.009470	2.06	8.06	12.35	0.81
Reach-1	7850	231 00	101 67	104 94	104.52	105.16	0.002830	2.79	259.45	197.33	0.54
Reach-1	7861.2	20 00	102 09	103 18	103.18	103.68	0.012144	3.13	6.38	11.04	1.00
Reach-1	7861.2	38 00	102 09	103 72	103.72	104.48	0.010504	3.88	9.80	18.03	1.00
Reach-1	7861.2	48 20	102 09	104 28	104.28	104.52	0.002999	2.55	72.82	188.84	0.56
Reach-1	7861.2	54 90	102 09	104 34	104.34	104.58	0.003130	2.66	83.83	191.51	0.58
Reach-1	7861.2	61 30	102 09	104 39	104.39	104.63	0.003247	2.75	93.44	193.80	0.59
Reach-1	7861.2	65 00	102 09	104 41	104.41	104.66	0.003323	2.80	98.50	195 00	0.60

HEC-RAS Plan: iadp-rep River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	8250	75 80	107.32	109.40	109.40	109.79	0.006070	3.30	59.22	101.49	0.77
Reach-1	8250	16.60	107 32	108.28	108.28	108.61	0.012287	2.56	7.38	15.73	0.94
Reach-1	8250	231.00	107.32	110.11	110.11	110.48	0.006312	4.18	199.90	224.78	0.83
Reach-1	8300	20 00	108 36	109.24	109.24	109.56	0.019048	2.51	7.96	12.60	1.01
Reach-1	8300	38.00	108.36	109.60	109.60	110.04	0.017124	2.97	12.80	14.43	1.01
Reach-1	8300	48.20	108.36	109.76	109.76	110.27	0.016077	3.15	15.36	16.04	1.00
Reach-1	8300	54.90	108.36	109.87	109.87	110.41	0.015434	3.25	17.17	19.70	0.99
Reach-1	8300	61.30	108.36	109.97	109.97	110.52	0.014603	3.31	19.42	24.63	0.97
Reach-1	8300	65.00	108.36	110.03	110.03	110.59	0.013851	3.33	21.03	29.70	0.96
Reach-1	8300	75 80	108.36	110.24	110.24	110.75	0.010711	3.24	29.65	53.99	0.86
Reach-1	8300	16.60	108.36	109.16	109.16	109.45	0.019688	2.39	6.95	12.18	1.01
Reach-1	8300	231.00	108.36	111.20	111.20	111.49	0.005468	3.26	235.14	324.98	0.67
Reach-1	8313.1	20.00	108.75	109.84		110.14	0.013639	2.40	8.38	12.14	0.87
Reach-1	8313.1	38.00	108.75	110.18	110.18	110.67	0.014342	3.13	13.36	16.39	0.95
Reach-1	8313.1	48.20	108.75	110.37	110.37	110.92	0.012983	3.32	16.67	17.37	0.93
Reach-1	8313.1	54.90	108 75	110.42	110.42	111.07	0.014821	3.63	17.50	17.61	1.00
Reach-1	8313.1	61.30	108.75	110.48	110.48	111.21	0.015750	3.86	18.61	17.92	1.04
Reach-1	8313.1	65.00	108.75	110.69	110.69	111.29	0.010856	3.51	24.32	30.07	0.88
Reach-1	8313.1	75.80	108.75	110.88	110.88	111.47	0.009686	3.57	30.24	33.95	0.85
Reach-1	8313.1	16.60	108.75	109.77		110.02	0.012910	2.20	7.54	10.89	0.84
Reach-1	8313.1	231.00	108.75	112.03	112.03	112.34	0.004738	3.47	256.10	337.15	0.64
Reach-1	8313.2	20.00	109 14	110.35	110.35	110.88	0.017109	3.24	6.18	8.87	1.00
Reach-1	8313.2	38.00	109 14	110.92	110.92	111.73	0.014776	4.00	9.50	22.76	1.00
Reach-1	8313.2	48 20	109.14	111.20	111.20	112.15	0.014041	4.33	11.12	29.57	1.00
Reach-1	8313.2	54.90	109.14	111.37	111.37	112.42	0.013603	4.52	12.14	33.61	1.00
Reach-1	8313.2	61.30	109.14	111.78	111.78	112.06	0.004248	2.85	58.81	123.67	0.57
Reach-1	8313.2	65.00	109 14	111.78	111.78	112.10	0.004776	3.02	58.81	123.67	0.61
Reach-1	8313.2	75 80	109 14	111.86	111.86	112.20	0.005240	3.23	69.41	142.33	0.64
Reach-1	8313.2	16.60	109.14	110.22	110.22	110.69	0.018085	3.05	5.44	8.54	1.01
Reach-1	8313.2	231 00	109.14	112.55	112.55	112.82	0.005758	3.96	263.26	321.21	0.70
Reach-1	8313.3	20.00	109.14	110.49		110.91	0.014815	2.84	7.04	5.80	0.82
Reach-1	8313.3	38.00	109.14	111.60	111.09	111.80	0.005458	2.25	32.05	76.48	0.47
Reach-1	8313.3	48.20	109.14	112.21	111.34	112.25	0.001263	1.27	148.71	312.55	0.24
Reach-1	8313.3	54.90	109.14	112.51		112.52	0.000484	0.84	242.51	320.25	0.15
Reach-1	8313.3	61.30	109.14	111.76		112.09	0.008893	3.00	47.45	115.51	0.61
Reach-1	8313.3	65.00	109.14	111.73		112.13	0.010740	3.28	44.81	109.80	0.67
Reach-1	8313.3	75.80	109.14	111.86		112.21	0.009684	3.23	61.34	141.77	0.64
Reach-1	8313.3	16.60	109.14	110.36		110.72	0.014357	2.65	6.27	5.80	0.81
Reach-1	8313.3	231.00	109.14	112.76		112.84	0.003800	2.47	324.76	326.66	0.42
Reach-1	8313.35	Bridge									
Reach-1	8313.4	20.00	109.14	110.59	110.34	110.94	0.011937	2.63	7.84	9.98	0.74
Reach-1	8313.4	38.00	109.14	111.68	111.09	111.84	0.004319	2.05	39.18	96.52	0.42
Reach-1	8313.4	48.20	109.14	112.23	111.34	112.26	0.001168	1.22	153.91	312.98	0.23
Reach-1	8313.4	54.90	109.14	112.51	111.42	112.52	0.000477	0.83	243.91	320.36	0.15
Reach-1	8313.4	61.30	109.14	112.02	111.46	112.23	0.005434	2.51	89.62	307.59	0.48
Reach-1	8313.4	65.00	109.14	112.03	111.48	112.25	0.005738	2.59	93.15	307.89	0.50
Reach-1	8313.4	75.80	109.14	112.14	111.89	112.29	0.004344	2.31	127.64	310.79	0.44
Reach-1	8313.4	16.60	109.14	110.44	110.22	110.75	0.011700	2.47	6.72	5.80	0.73
Reach-1	8313.4	231.00	109.14	112.80	112.47	112.87	0.003445	2.36	336.04	327.53	0.40
Reach-1	8313.5	20.00	109.14	110.61	110.34	110.95	0.011485	2.60	7.69	10.47	0.72
Reach-1	8313.5	38.00	109.14	111.48	110.92	111.93	0.009915	2.97	12.78	27.57	0.64
Reach-1	8313.5	48 20	109.14	112.23	111.20	112.26	0.001162	1.22	154.28	313.01	0.23
Reach-1	8313.5	54.90	109.14	112.51	111.36	112.52	0.000476	0.83	244.06	320.37	0.15
Reach-1	8313.5	61.30	109.14	112.01	111.52	112.24	0.005711	2.57	86.82	307.36	0.50
Reach-1	8313.5	65 00	109.14	112.01	111.60	112.27	0.006463	2.73	86.46	307.33	0.53
Reach-1	8313.5	75.80	109.14	112.16	111.93	112.29	0.003943	2.21	133.68	311.30	0.42
Reach-1	8313.5	16.60	109.14	110.47	110.22	110.76	0.010942	2.41	6.88	5.80	0.71
Reach-1	8313.5	231.00	109.14	112.80	111 99	112.87	0.003407	2.35	337.35	327.63	0 40
Reach-1	8313.6	20.00	109 20	110.75		111.01	0.005678	2.28	10.27	9.01	0.61
Reach-1	8313.6	38.00	109.20	111.83		111.99	0.002066	1.99	41.92	52.29	0.40
Reach-1	8313.6	48.20	109.20	112.19		112.29	0.001398	1.79	92.46	235.42	0.34
Reach-1	8313.6	54.90	109.20	112.49		112.54	0.000694	1.35	173.44	296.62	0.24
Reach-1	8313.6	61 30	109 20	111 99		112.29	0.003809	2.82	50.74	57.28	0.55
Reach-1	8313.6	65.00	109 20	111.99		112.32	0.004321	3 00	50.50	57.15	0.59

HEC-RAS Plan: jadb-rep River: RIVER 1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Reach-1	8313.6	75.80	109.20	111.92		112.44	0.006792	3.70	46.66	55.03	0.71
Reach-1	8313.6	16.60	109.20	110.59		110.82	0.005982	2.16	8.81	8.68	0.61
Reach-1	8313.6	231.00	109.20	112.78	112.78	113.07	0.005349	3.97	262.48	313.72	0.68
Reach-1	8450	20.00	110.28	111.64	111.64	111.95	0.019127	2.45	8.62	17.51	0.98
Reach-1	8450	38.00	110.28	112.00	112.00	112.37	0.015918	2.78	16.26	25.23	0.94
Reach-1	8450	48.20	110.28	112.23		112.57	0.012080	2.69	22.43	28.80	0.84
Reach-1	8450	54.90	110.28	112.44		112.72	0.008564	2.45	28.91	32.12	0.73
Reach-1	8450	61.30	110.28	112.33		112.77	0.014570	3.07	25.38	30.36	0.94
Reach-1	8450	65.00	110.28	112.38		112.82	0.014070	3.08	27.06	31.21	0.92
Reach-1	8450	75.80	110.28	112.63		112.99	0.010076	2.83	35.17	34.15	0.80
Reach-1	8450	16.60	110.28	111.56	111.56	111.84	0.019706	2.33	7.29	15.78	0.98
Reach-1	8450	231.00	110.28	113.73	113.73	114.26	0.008266	3.74	122.09	145.78	0.79
Reach-1	8500	20.00	111.67	112.63	112.59	112.83	0.016291	2.01	9.96	26.21	0.89
Reach-1	8500	38.00	111.67	112.87	112.85	113.21	0.017074	2.57	14.78	34.58	0.96
Reach-1	8500	48.20	111.67	112.98	112.98	113.39	0.017733	2.83	17.03	38.33	1.00
Reach-1	8500	54.90	111.67	113.05	113.05	113.50	0.017524	2.95	18.59	40.04	1.01
Reach-1	8500	61.30	111.67	113.13	113.13	113.60	0.016927	3.04	20.19	41.46	1.00
Reach-1	8500	65.00	111.67	113.17	113.17	113.65	0.016749	3.09	21.05	42.21	1.00
Reach-1	8500	75.80	111.67	113.27	113.27	113.81	0.016600	3.25	23.33	44.19	1.01
Reach-1	8500	16.60	111.67	112.57	112.53	112.75	0.016532	1.88	8.81	24.15	0.88
Reach-1	8500	231.00	111.67	114.26	114.26	114.89	0.011140	3.89	95.43	99.69	0.90

APPENDIX-D

CULVERT/BRIDGE STRUCTURE SIZING SUMMARY

CULVERT/BRIDGE CROSSING SUMMARY

A. - Red Hill Creek - Main Branch and Davis Creek - Structures

Location	Station	Type of Structure	Required size based on various functions [Span (m) x Height (m)]					
			Flood Conveyance	Terrestrial	Stream Morphology	Trails/Access	Visual Resources	Estimate of Ultimate Crossing Configuration and Comment
Mainline	28+725	Bridge	30 m x 4 m	30 m span (total) x 4m to 10 m height	24 m (clear span - no piers) Note: potential to use piers subject to final design			30 m x 4 m bridge
CNR	28+600	Channel through End Span	10 m x 4 m					17 m x 4 m channel plus retention of existing culverts
Mainline	28+260	Culvert/Bridge	14 m x 2.5 m					24 m x 2.5 m culvert/bridge (maximum clear span 12-14 m due to available clearance)
Barton	28+100	Channel through End Span	12 m x 4 m					24 m x 4 m channel
Ramp E/W -S Queenston	9+940	Culvert/Bridge	12 m x 3.3 m (opening measured perpendicular to flow)					120m span bridge (clearance ranges from 1.2 m to 4 m)
Ramp N-E/W Queenston	9+820	Culvert/Bridge	33.0 m x 2.0m					33.0 m x 5.0m bridge
Queenston Road	26+775	Channel through End Span	14 m x 4 m (maximum available)		May require additional supplemental conveyance culverts			14m x 4m channel (maximum available) may require additional supplemental conveyance culverts
Ramp N-E/W King	10+140	Culvert/Bridge	12 m x 3.3 m		24 metre (clear span - no piers) Note: potential to use piers subject to final design			24 m x 3.3m culvert/bridge (maximum clear span 12-14 m culvert)
Ramp E/W - S King	10+160	Culvert/Bridge	12 m x 3.3 m					24 m x 3.3m culvert/bridge (maximum clear span 12-14 m for culvert)
King Street	25+950	Triple Cell Culvert	15 m x 2.7 m		May require additional supplemental conveyance culverts			15 m x 2.7 m triple cell culvert may require additional supplemental conveyance culvert/ may also provide terrestrial migration
Lawrence - Mount Albion Access	25+575	High Level Bridge	N/A	Requires consideration for pier and abutment location	Requires consideration for pier and abutment location			150-160 m span high level bridge
Mainline and Ramp (Davis Creek)	24+840	Culvert	1.5 m x 1.5 m	10 m x 4 m	N/A			10 m x 4 m culvert Note: Potential for single long or two shorter structures and salvage potential of existing structure to be determined
Ramp S-E/W King Davis Creek Stormwater Management Facility (existing structure)	10+315	Culvert - Stormwater Management Control Structure	Retrofit to 1.2 m x 1.2 m opening (Existing Opening: Twin- 5 x 3.25 m) Requires drop inlet overflow to existing opening	Larger opening at higher level (above flood level) acceptable	Larger opening preferred to convey sediment, however will not significantly affect Red Hill Creek morphology			1.2 m by 1.2 metre height culvert (size limitation required for SWM) (would involve inlet retro- fit of the upstream side of the existing culvert with drop inlets to protect from debris obstruction and provide overflow conveyance) + additional Terrestrial opening at higher level 5 m x 2.5 m size (estimated)
TH&B	25+460	Triple Cell Culvert	10.9 m x 2.8 m	30 m span (total) x 4 m to 10 m height	May require additional supplemental conveyance culverts			10.9 m (total) x 2.8 m triple cell culvert may require additional supplemental conveyance culverts which may provide terrestrial migration as well
Mainline	25+350	Culvert - SWM control structure (overflow and local drainage)	1 2 m x 1.2 m	No comments received (assume 2 m x 1 m)	N/A			1.2 m x1.2 m (size limitation required for SWM)
Mainline	25+025	Culvert - SWM control structure (overflow and local drainage)	2.0 m x 1.0m	No comments received (assume 2 m x 1 m)	N/A			2.0 m x 1.0 m (size limitation required for SWM)
Greenhill Stormwater Management Facility	25+150 (located west of Expressway)	Culvert - SWM control Structure	8.0 m x 1.4 m	Potential to provide terrestrial migration over SWM embankment	8.0 m x 1.4 m acceptable			8.0 m x 1.4 m culvert (size limitation required for SWM)

CULVERT/BRIDGE CROSSING SUMMARY

B. Other Crossings
(includes Local Drainage, Stormwater Management Control, Equalization)

Location	Station	Type	Required size based on various functions [Span (m) x Height (m)]					
			Flood Conveyance	Terrestrial	Stream Morphology	Trails/Access	Visual Resources	Estimate of Ultimate Crossing Configuration
Mainline	28+475	Culvert	1.0 m dia. (est.)	2.0 m x 1.0 m	N/A			2.0 m x 1.0 m
Mainline	28+040	Culvert	2.3 m x 1.5 m					2.3 m x 1.5 m (outlet for SWM facility treating 202 ha external drainage area)
Mainline and Ramp (Expressway North - Barton E/W)	27+925	Culvert	1.0 m dia. (est.)					2.0 m x 1.0 m
Mainline	27+775	Culvert	2.0 m x 2.0 m.					2.0 m x 2.0 m. (flood flow equalization)
Mainline	27+475	Culvert	1.0 m dia. (est.)					2.0 m x 1.0 m
Mainline	27+125	Culvert	1.5 m x 1.0 m					2.0 m x 1.0 m (outlet for SWM facility treating 63 ha external drainage area)
Mainline and Ramp (Expressway North - Queenston E/W)	26+675	Culvert	1.0 m dia. (est.)					2.0 m x 1.0 m Note: Location and potential for single long or two shorter structures to be determined. Potential to connect to supplemental culvert @ Queenston
Mainline and Ramp	26+160	Culvert	2.0 m x 2.0 m.					2.0 m x 2.0 m (flood flow equalization).
Mainline	24+800	Culvert	No culvert required however storm sewer system would outlet at this point					Culvert not required
Mainline	24+400	Culvert	0.9 m dia.					2.0 m x 1.0 m

APPENDIX-E

STORMWATER QUALITY

MASS BALANCE MODEL RESULTS

Table E.1
Red Hill Creek Expressway - Impact Prediction and Mitigation
Mud St. to Brampton St.
Summary of Predicted Annual Loading to Red Hill Creek

Parameter	Loading (kg/year)				
	Existing Land Use[1]	Existing with Expressway[1]	% change	Expressway[1] and Mitigation	% change
TSS	2071819	2113220	2.00	1948846	-5.94
BOD	123474	130823	5.95	123319	-0.13
Copper	358	395	10.35	355	-0.81
Zinc	2773	2876	3.73	2758	-0.52
Fecal col.	5.035E+15	5.037E+15	0.05	4.75E+15	-5.72
PAH	17.05	17.76	4.14	16.46	-3.50
T. Phos.	4280	4397	2.74	4151	-3.00

[1] Existing Land Use based on watershed upstream of Queenston Road

[2] total counts/year

Pollutant Removal Rates used in Model

Parameter	Removal Efficiencies (%)			
	Wetland Designed for Level 1 Habitat Protection	Wetland Designed for External Land Use Drainage	Wetpond Designed for Level 2 Habitat Protection	Grassed Swale Riparian Buffers
TSS	80	56-57	70	50
BOD	45	28	30	60
Copper	65	28	57	60
Zinc	55	28	33	60
Fecal col.	80	58	68	80
PAH	70	50	52	70
T. Phos.	55	40	32	60

Red Hill Expressway - Impact Prediction and Mitigation
Mud Street to Brampton Street
Estimated Change in Annual Pollutant Loading to Red Hill Creek

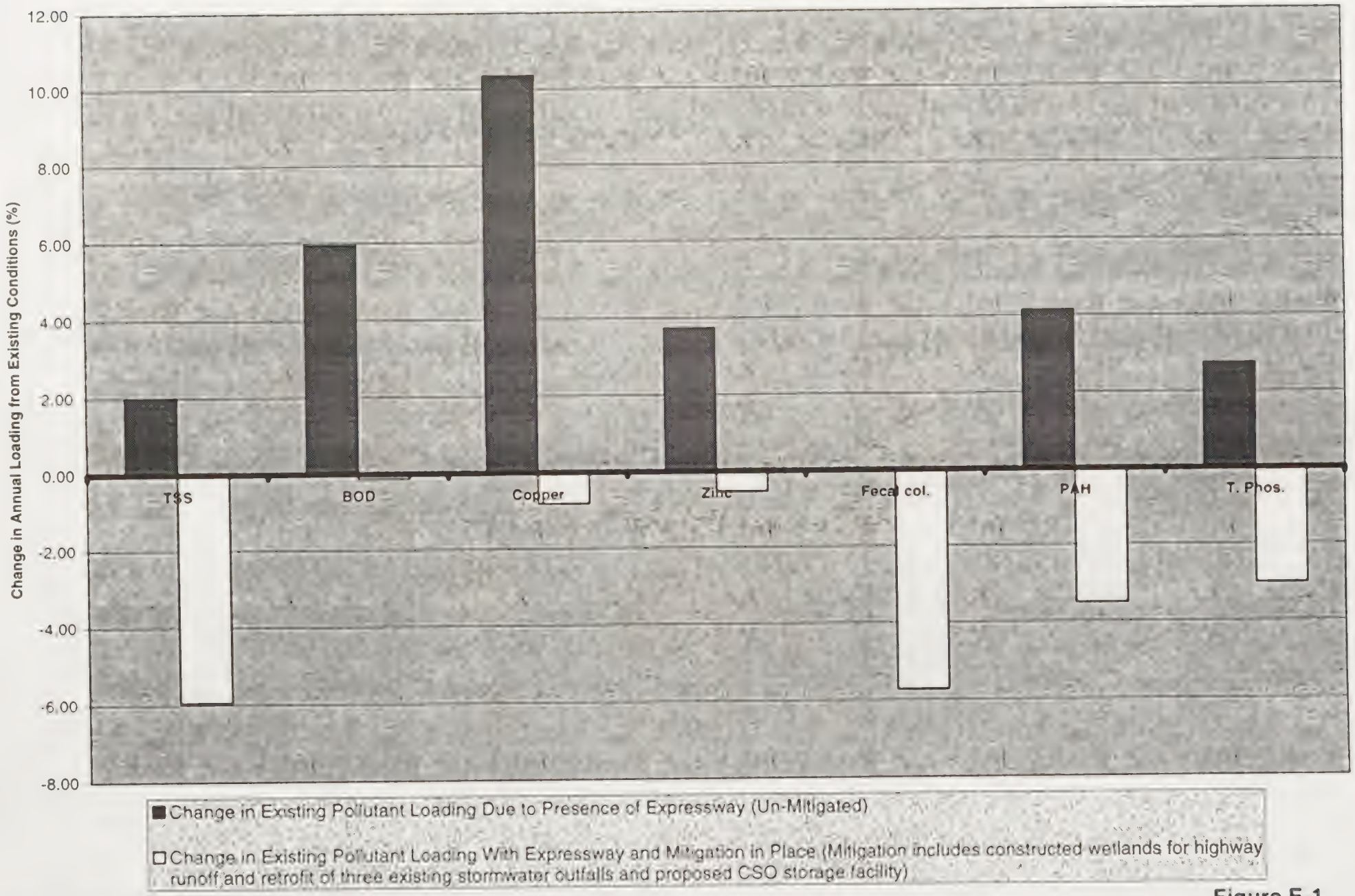


Figure E-1

Table E-2
Red Hill Creek Expressway - Impact Prediction and Mitigation
Summary of Annual Pollutant Loading
QEW (Highway 20 to Burlington Street): OPTION A

OPTION SUMMARY	
Existing Pavement Area	15.6 ha
Proposed Pavement Area	22.8 ha
Percent of Total Pavement Area Treated by Constructed Wetlands	40%
Percent of Total Pavement Area Treated by Grassed Swales with Buffer Strips	56%
Percent Not Treated	4%

LOADING FOR VARIOUS LAND USE CONDITIONS					
Parameter	**Existing[1]**	**Existing with Hwy Interchange Works**	**Change from Exisiting to with Highway**	**Mitigated Conditions**	**Change from Exisiting to Mitigated**
	(kg/year)	(kg/year)	(%)	(kg/year)	(%)
BOD5	126346	127671	1.0	125494	-0.7
TSS	2089769	2098053	0.4	2080727	-0.4
Copper	375	382	2.0	368	-1.8
Zinc	2813	2832	0.7	2801	-0.4
Fecal Col.[2]	5.04E+15	5.04E+15	0.0	5.04E+15	0.0
Total Phos.	4328	4350	0.5	4310	-0.4
PAH	17.33	17.46	0.7	17.19	-0.8

[1] Includes external land use from Queenston Road to Mud St

[2] Counts/year

ASSUMED REMOVAL EFFICIENCIES (%)		
Parameter	**Wetland Designed for Level 1 Habitat Protection**	**Grassed Swale Riparian Buffers**
TSS	80	50
BOD	45	60
Copper	50	60
Zinc	50	60
Fecal col.	80	80
PAH	70	70
T. Phos.	55	60

Red Hill Creek Expressway - Impact Prediction and Mitigation
Stormwater Quality - QEW(Highway 20 to Burlington Street) - OPTION A
Estimated Change in Annual Pollutant Loading to Red Hill Creek

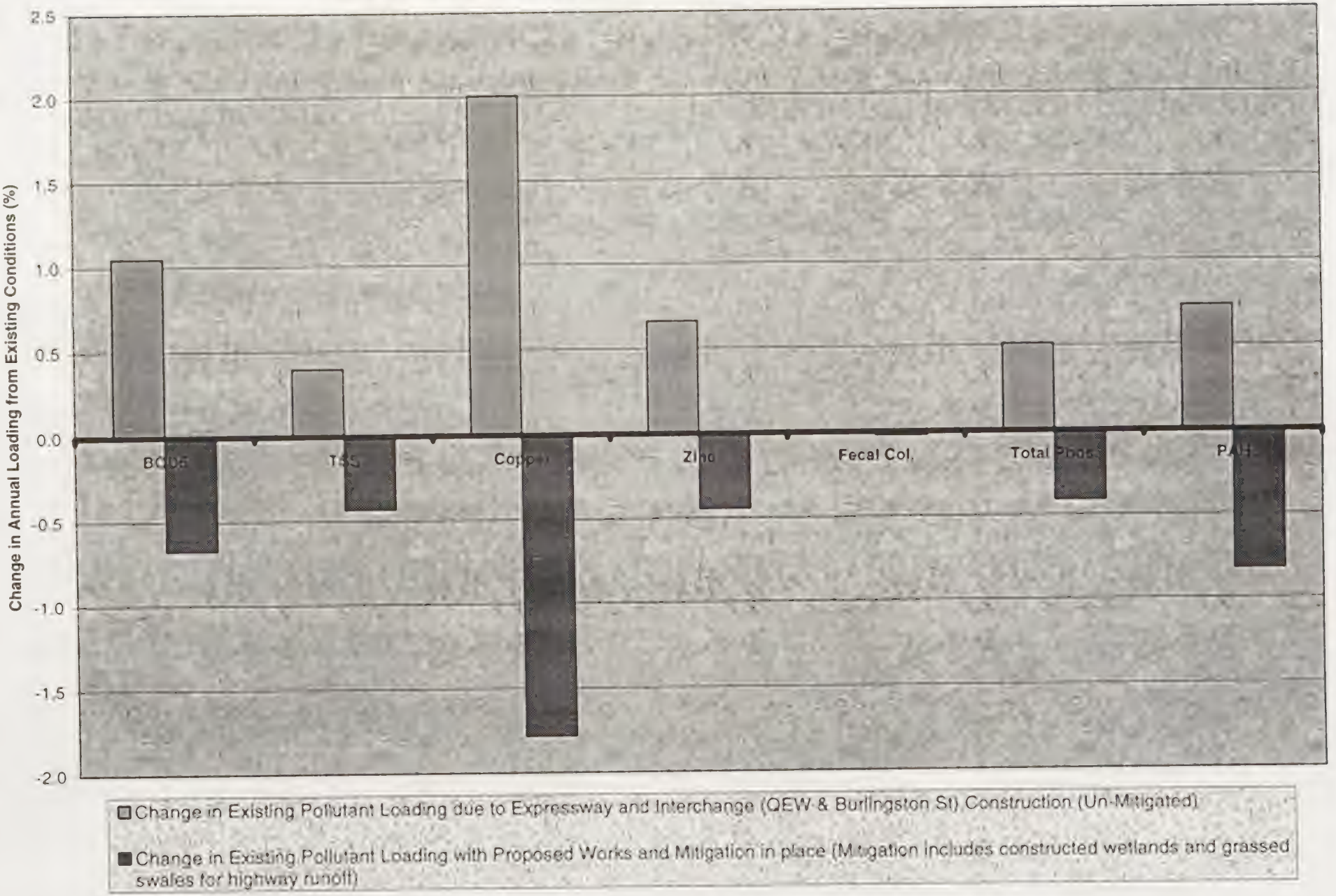


Figure E-2

Table E.3
Red Hill Creek Expressway - Impact Prediction and Mitigation
QEW (Highway 20 to Burlington St): OPTION B

OPTION SUMMARY	
Existing Pavement Area	15.6 ha
Proposed Pavement Area	22.6 ha
Percent of Total Pavement Area Treated by Constructed Wetlands	44%
Percent of Total Pavement Area Treated by Grassed Swales with Buffer Strips	51%
Percent Not Treated	4%

LOADING FOR VARIOUS LAND USE CONDITIONS					
Parameter	**Existing[1]**	**Existing with Hwy Interchange Works**	**Change from Exisiting to with Highway**	**Mitigated Conditions**	**Change from Exisiting to Mitigated**
	(kg/year)	(kg/year)	(%)	(kg/year)	(%)
BOD5	126346	127634	1.0	125505	-0.7
TSS	2089769	2097823	0.4	2080307	-0.5
Copper	375	382	1.9	368	-1.8
Zinc	2813	2831	0.6	2800	-0.5
[2] Fecal Col.	5.04E+15	5.04E+15	0.0	5.04E+15	0.0
Total Phos.	4328	4349	0.5	4310	-0.4
PAH	17.33	17.45	0.7	17.18	-0.8

[1] Includes external land use from Queenston Road to Mud St

[2] Counts/year

ASSUMED REMOVAL EFFICIENCIES (%)		
Parameter	**Wetland Designed for Level 1 Habitat Protection**	**Grassed Swale Riparian Buffers**
TSS	80	50
BOD	45	60
Copper	50	60
Zinc	50	60
Fecal col.	80	80
PAH	70	70
T. Phos.	55	60

Red Hill Creek Expressway - Impact Prediction and Mitigation
Stormwater Quality QEW (Highway 20 to Burlington Street) - OPTION B
Estimated Change in Annual Pollutant Loading to Red Hill Creek

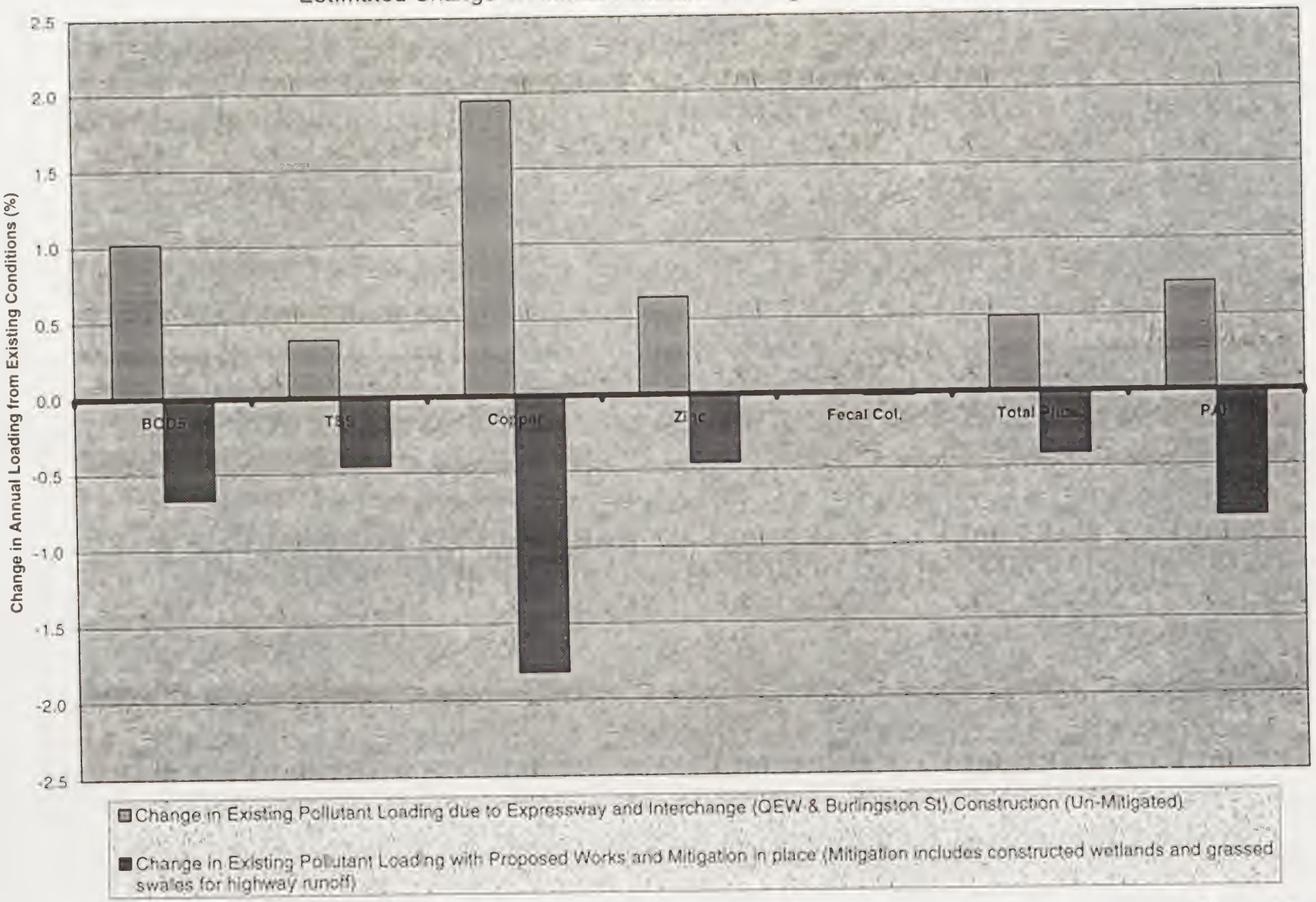


Figure E-3

Table E.4
Red Hill Creek Expressway - Impact Prediction and Mitigation
QEW (Highway 20 to Burlington St.): OPTION C/C-1

OPTION SUMMARY	
Existing Pavement Area	15.6 ha
Proposed Pavement Area	25.7 ha
Percent of Total Pavement Area Treated by Constructed Wetlands	29%
Percent of Total Pavement Area Treated by Grassed Swales with Buffer Strips	68%
Percent Not Treated	4%

LOADING FOR VARIOUS LAND USE CONDITIONS					
Parameter	**Existing[1]**	**Existing with Hwy Interchange Works**	**Change from Exisiting to with Highway**	**Mitigated Conditions**	**Change from Exisiting to Mitigated**
	(kg/year)	(kg/year)	(%)	(kg/year)	(%)
BOD5	126346	128205	1.5	125667	-0.5
TSS	2089769	2101390	0.6	2083562	-0.3
Copper	375	385	2.8	369	-1.4
Zinc	2813	2839	0.9	2804	-0.3
[2] Fecal Col.	5.04E+15	5.04E+15	0.0	5.04E+15	0.0
Total Phos.	4328	4358	0.7	4313	-0.3
PAH	17.33	17.51	1.0	17.20	-0.7

[1] Includes external land use from Queenston Road to Mud St

[2] Counts/year

ASSUMED REMOVAL EFFICIENCIES (%)		
Parameter	**Wetland Designed for Level 1 Habitat Protection**	**Grassed Swale Riparian Buffers**
TSS	80	50
BOD	45	60
Copper	50	60
Zinc	50	60
Fecal col.	80	80
PAH	70	70
T. Phos.	55	60

Red Hill Creek Expressway - Impact Prediction and Mitigation
Water Quality - QEW (Highway 20 to Burlington Street - OPTION C/C-1
Estimated Change in Annual Pollutant Loading to Red Hill Creek

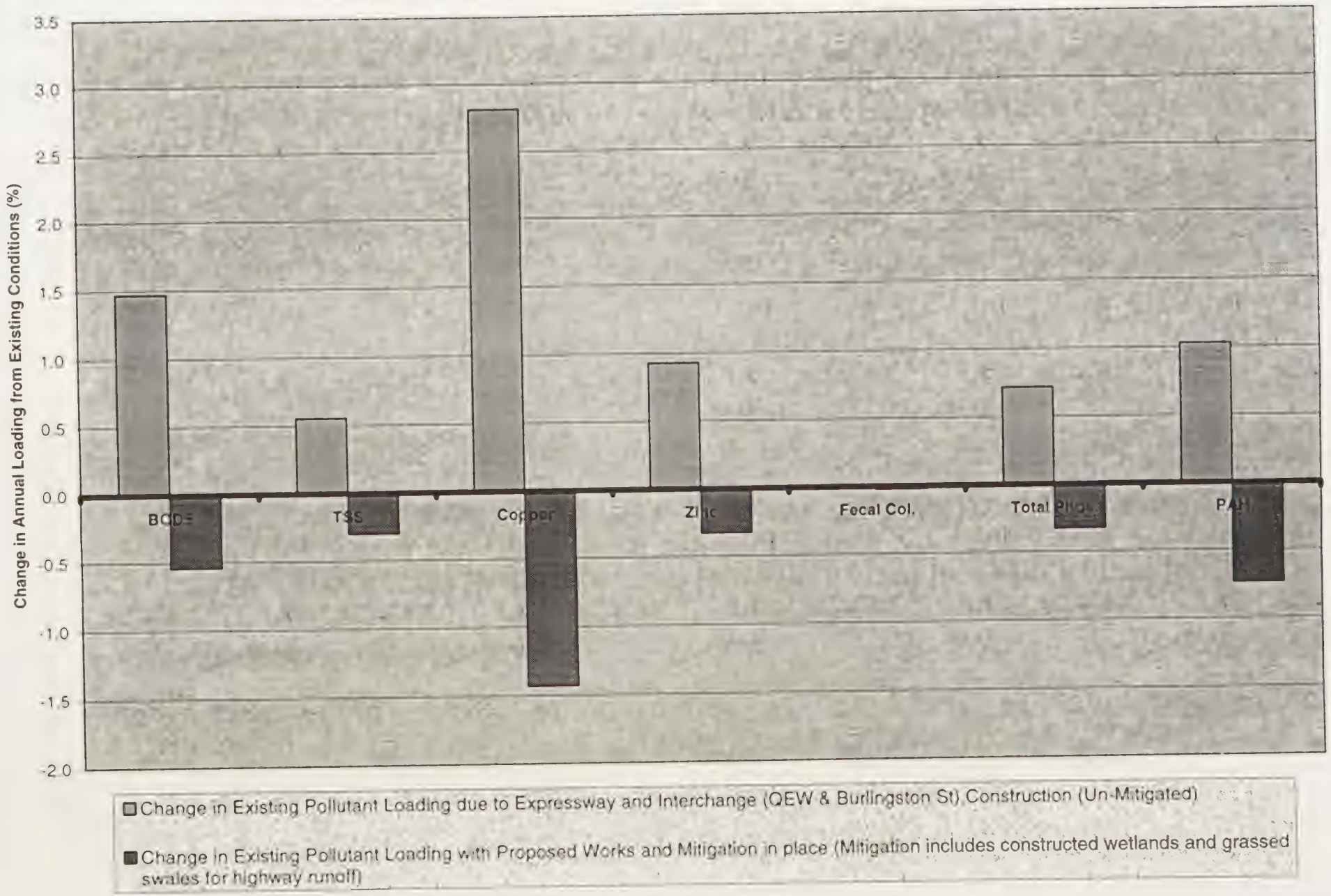
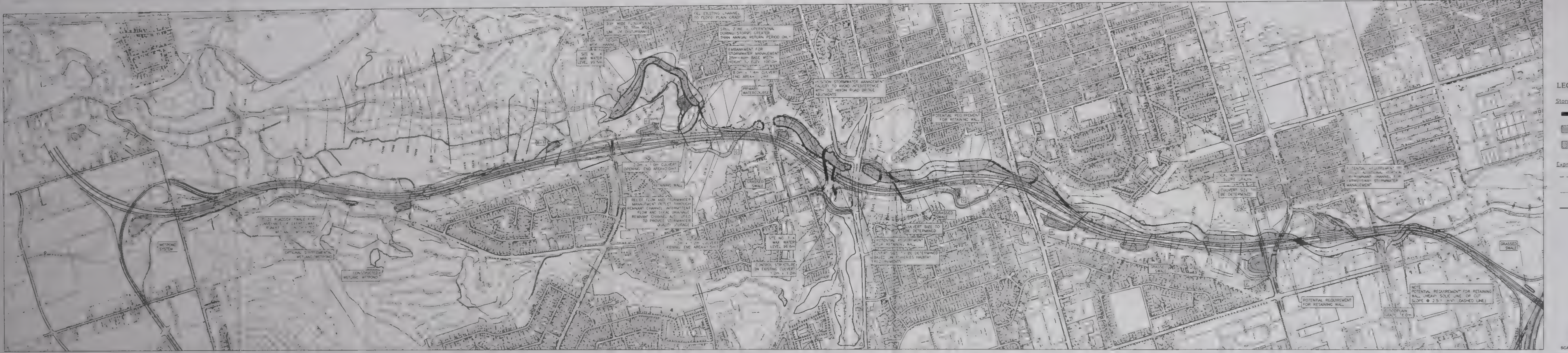


Figure E-4



RED HILL CREEK EXPRESSWAY

Impact Assessment and Design Process
Surface Water and Stormwater Quality
Technical Report

REGION OF HAMILTON-WENTWORTH
Transportation Department, Special Projects Office

LEGEND

Stormwater

- CULVERT/BRIDGE LOCATION
- STORMWATER FACILITY LOCATION
- FLOODPLAIN EXCAVATION

Expressway

- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (FILL)
- LIMIT OF DISTURBANCE GRADING FOR EXPRESSWAY (CUT)
- RETAINING WALL

Stream

- LIMIT OF MINIMUM FLOODPLAIN/BELTWIDTH (Inner Line)
- LIMIT OF DISTURBANCE/GRADING (4:1 (H:V) SIDE SLOPE) (Outer Line)
- LOCAL SLOPE ADJUSTMENT STEEPER THAN 4:1 SLOPE TO MATCH EXISTING GROUND
- DISTURBANCE LIMITED TO CONSTRUCTION OF 8m CHANNEL - REF NOTE 1
- FLOODPLAIN GRADING/DISTURBANCE FULL WIDTH REQUIRED - REF NOTE 1

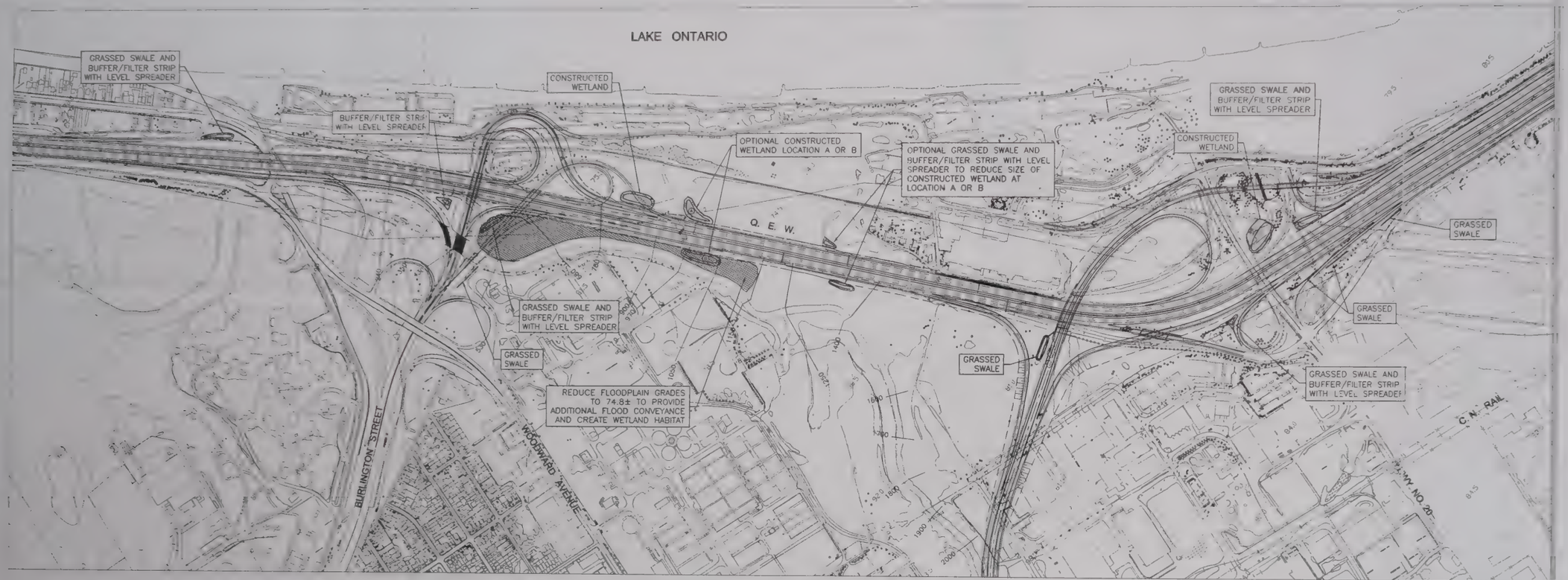
NOTE 1

SEPARATION BETWEEN "MINIMUM FLOODPLAIN BELTWIDTH" AND "LIMIT OF DISTURBANCE" INDICATES THE RELATIVE EXTENT OF GRADING REQUIRED (i.e. WHERE FLOODPLAIN AND GRADING LIMITS ARE COINCIDENT NO FLOODPLAIN GRADING IS REQUIRED.

FIGURE NO. 1
Stormwater Management Mitigation Opportunities
Mud Street to Brampton Street

SCALE 1:8500

Philips Planning + Engineering Limited



RED HILL CREEK EXPRESSWAY

Impact Assessment and Design Process
Surface Water and Stormwater Quality
Technical Report

REGION OF HAMILTON-WENTWORTH
Transportation Department, Special Projects Office

LEGEND

Stormwater

- CULVERT/BRIDGE LOCATION
- STORMWATER FACILITY LOCATION
- FLOODPLAIN EXCAVATION

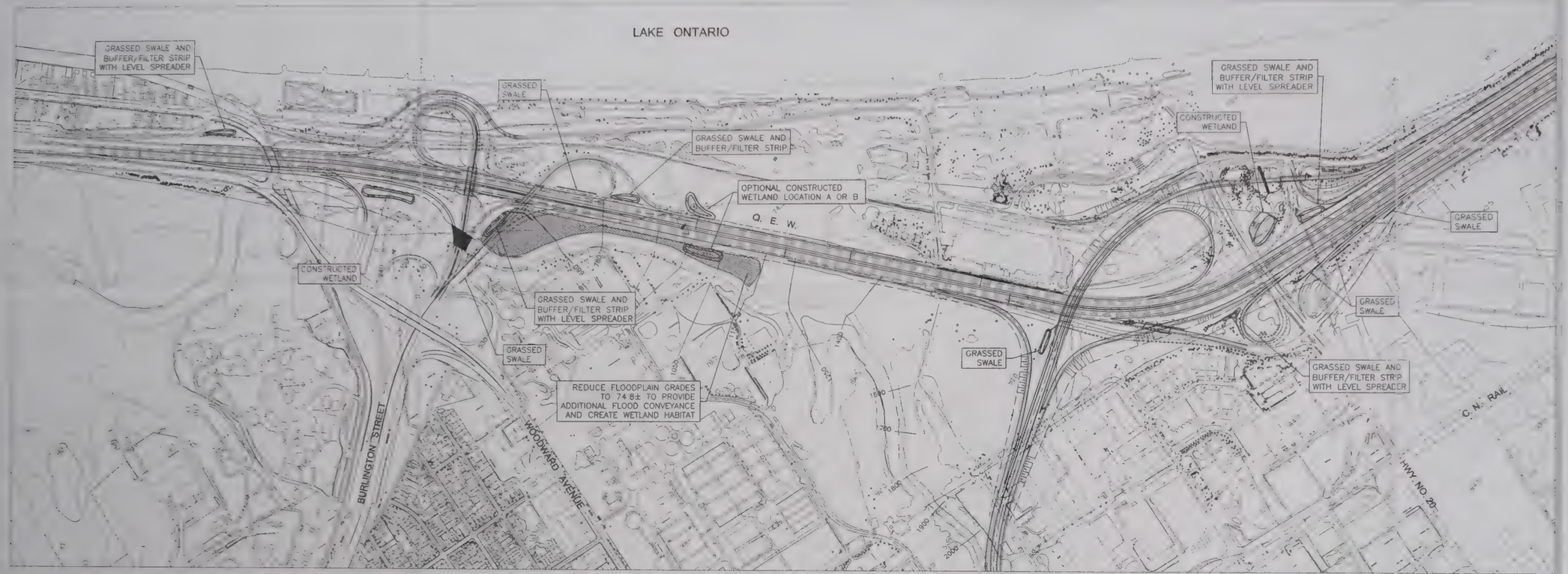
Expressway

- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (FILL)
- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (CUT)
- RETAINING WALL

FIGURE NO. 2
Stormwater Management Mitigation Opportunities
QEW (Highway 20 to Burlington Street)
OPTION 'A'

SCALE 1 : 5000

Philips Planning Engineering Limited



RED HILL CREEK EXPRESSWAY

Impact Assessment and Design Process
Surface Water and Stormwater Quality
Technical Report

REGION OF HAMILTON-WENTWORTH
Transportation Department, Special Projects Office

LEGEND

Stormwater

- CULVERT/BRIDGE LOCATION
- STORMWATER FACILITY LOCATION
- FLOODPLAIN EXCAVATION

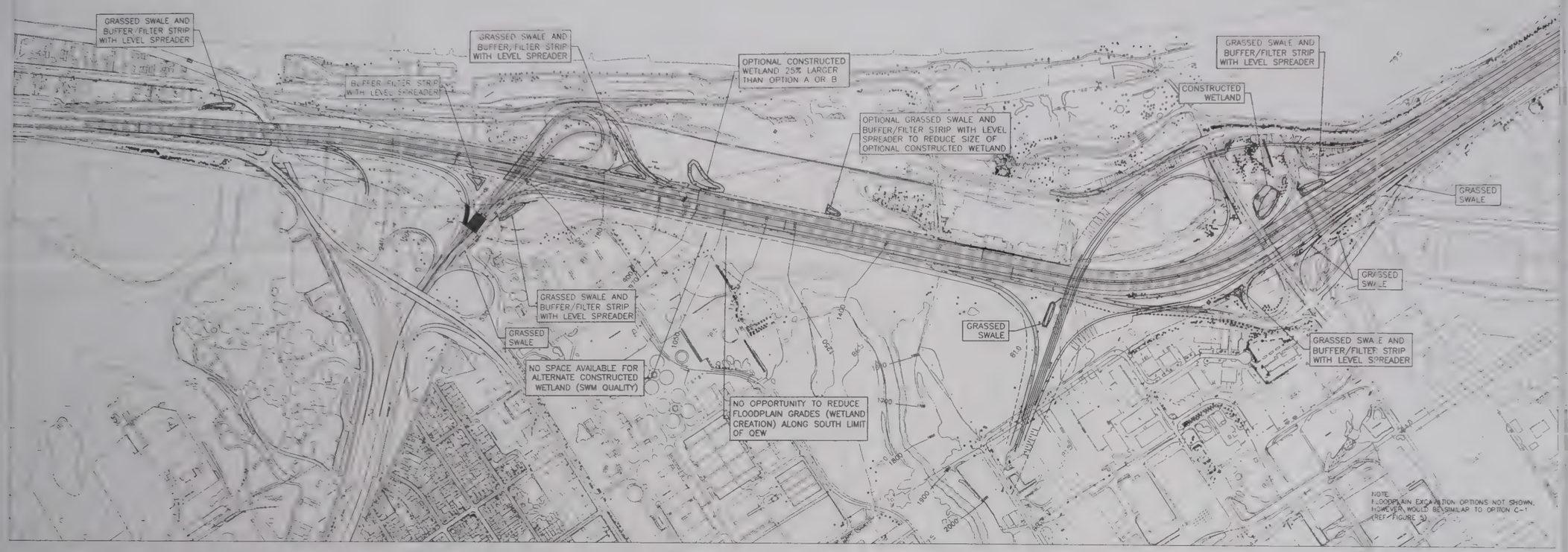
Expressway

- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (FILL)
- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (CUT)
- RETAINING WALL

FIGURE NO. 3
Stormwater Management Mitigation Opportunities
QEW (Highway 20 to Burlington Street)
OPTION 'B'

SCALE 1 : 5000

Philips Planning Engineering Limited



RED HILL CREEK EXPRESSWAY

Impact Assessment and Design Process
Surface Water and Stormwater Quality
Technical Report

REGION OF HAMILTON-WENTWORTH
Transportation Department, Special Projects Office

LEGEND

Stormwater

- CULVERT/BRIDGE LOCATION
- STORMWATER FACILITY LOCATION

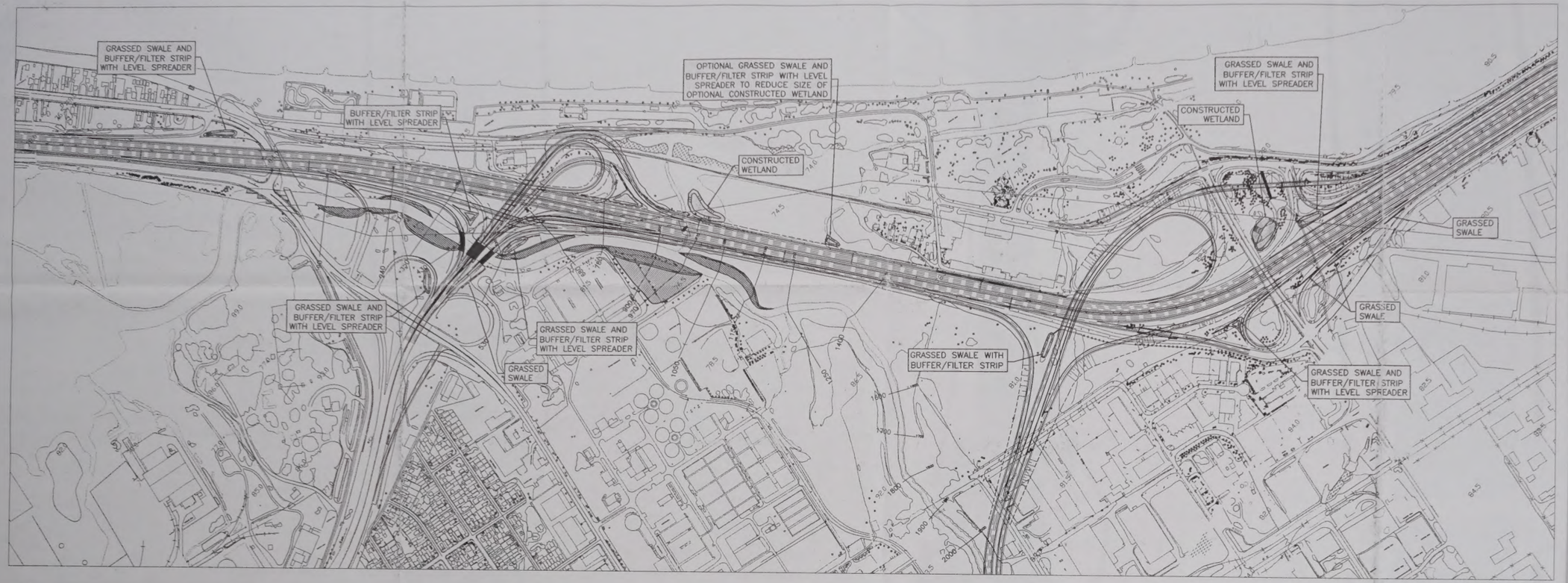
Expressway

- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (FILL)
- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (CUT)
- RETAINING WALL

FIGURE NO. 4
Stormwater Management Mitigation Opportunities
QEW (Highway 20 to Burlington Street)
OPTION 'C'

SCALE 1 : 5000

Philips Planning Engineering Limited



RED HILL CREEK EXPRESSWAY

Impact Assessment and Design Process
Surface Water and Stormwater Quality
Technical Report

REGION OF HAMILTON-WENTWORTH
Transportation Department, Special Projects Office

LEGEND

Stormwater

- CULVERT/BRIDGE LOCATION
- STORMWATER FACILITY LOCATION
- PRIMARY FLOODPLAIN EXCAVATION TO PROVIDE ADDITIONAL FLOOD CONVEYANCE
- SUPPLEMENTAL FLOODPLAIN EXCAVATION TO PROVIDE ADDITIONAL FLOOD CONVEYANCE

Expressway

- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (FILL)
- LIMIT OF DISTURBANCE/GRADING FOR EXPRESSWAY (CUT)
- RETAINING WALL

FIGURE NO. 5
Stormwater Management Mitigation Opportunities
QEW (Highway 20 to Burlington Street)
OPTION 'C-1'

SCALE 1 : 5000

Philips Planning Engineering Limited


81.0
GRASSE
SWALE